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SEP 8 1921

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXII.—No. 2904.] *LONDON: FRIDAY, AUGUST 26, 1921.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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ROCHESTER.
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ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement, pages 31 and 81.
PATENT WATER-TUBE BOILERS,
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND.
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BIRMINGHAM. 7411
See Advertisement last week, page 109.

Plenty and Son,
LIMITED.
MARINE ENGINEERS, &c.
NEWBURY, ENGLAND. 9063

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 9105

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MULTITUBULAR AND CROSS-TUBE TYPES.
See page 17. 9108

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For Paraffin and Crude Oil.
Sizes 2½ B.HP. and upwards.
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SPECIALISTS
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SALE AND VALUATION
of
PLANT AND MACHINERY
and
ENGINEERING WORKS.
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Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 9746
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See Advertisement page 95, August 19.

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PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
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Worm Wheels cut up to 12 ft. diam.
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Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
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Oil Fuel Appliances.
SYSTEMS { PRESSURE, AIR, STEAM.
FOR BOILERS OF ALL TYPES.
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MESSRS. BUCKNALL & RICHES, 8, SOUTHAMPTON ROW, LONDON, W.C. 1.
Telephone No.: Museum 6084.
NAVAL OUTFITS A SPECIALTY. 4078

Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od 2437
See their Illus. Advertisement, page 118, last week.
RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

R. Y. Pickering & Co., Ltd.,
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
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VALUERS AND AUCTIONEERS
to the
ENGINEERING AND ALLIED TRADES.
ALSO FOR
PLANT AND MACHINERY. 8134
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Electric Lifts
(UP TO 35 TONS.)
9028
S. H. HENWOOD & CO., LTD. REDDISH.

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See Illustrated Advertisement Page 100, Jan. 28.

Locomotive Shunting Cranes

Steam and Electric Cranes,
EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS,
SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY. 9064
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John Bellamy, Limited,
MILLWALL, LONDON, E. 1316
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES.
HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes and Fittings.

Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 94. 9091

Machine and Engineering
WORK of all descriptions undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROSSER & RUSSELL, LTD., Queen's Wharf, Hammersmith.
NEW PATENT ACT.—ROSSER & RUSSELL, LTD., are prepared to undertake the manufacture of articles at present made abroad, and will be pleased to hear from firms desiring such work executed. 9011

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Gas Engines Inspected, Tested and Reported Upon. Over 25 years' experience. Tel.: 726 and 727 Stratford. Wire: "Rapidising, London."—Great Eastern Road, Stratford, E. 15. 1704

Diesel Engines, Six Cylinder,
two and four stroke, 850, 1000, 1200 H.P. Excellent condition. Dynamos for above 250 or 500 Volts, D.C. Immediate delivery and low price.
Also 2-500 Kw. PARSONS TURBINE SETS 250 or 500 Volts, D.C., with Condenser and spare armature.
ELECTRICALLY DRIVEN AIR COMPRESSORS, 250 Volts, D.C. Pressures 1500 to 3000 lbs. per square inch.
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West Walls, Newcastle-on-Tyne. 9088

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON AND BRASS CASTINGS.
PRESSED STEEL WORK OF ALL KINDS.
Registered Office and Chief Works: Motherwell.
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LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest references. Established 1900.
Address, BURNETT AVENUE, HULL.
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Augustin-Normand
67, rue de Perray—LE HAVRE (France). 2300
Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Electric Cranes.
9026
S. H. HENWOOD & CO., LTD., REDDISH.

The National Foremen's
ASSOCIATION OF THE ENGINEERING AND ALLIED TRADES.
(Registered under the Trade Union Act.)
An Association specially formed to look after the interests of Foremen on their Supervisory Capacity. F601
All communications to— Head Offices—
H. W. REID, General Secretary. 95, Belgrave Road Victoria, London, S.W. 1.

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION,
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
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Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES, Merrill's Patent TWIN STRAINERS for Pump Suctions. } Row's Patents
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5720

Yarrow Patent Water-tube Boilers.
9064
Messrs. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 9818
See Full Page Advt., page 74, Aug. 19.

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Walter Somers, Limited,
HALESOWEN. 7116

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS.
Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 9030
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Taylor & Challen Presses
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LARGE STOCK of NEW PRESSES now on view in our Showrooms, Constitution Hill.
TAYLOR & CHALLEN, LD., Engineers, BIRMINGHAM.
See Full Page Advertisement page 60, Aug. 19.

Patents DESIGNS AND TRADE MARKS IN ALL COUNTRIES.
E. P. Alexander & Son,
CHARTERED PATENT AGENTS,
899, HIGH HOLBORN, LONDON, W.C.
(Established 1874.)
Telephone: Central 7434. Od 886

Universal and Cutter Grinding MACHINES IN STOCK. Suitable for accurate internal and external grinding, surface grinding, and all kinds of cutter grinding. High Speed Hack Sawing Machines, 6 in. capacity.
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"OILDAG" (Reg.) BRAND. **"AQUADAG"** (Reg.) BRAND.
GRAPHITED GREASE.
"GREDAG"
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E. G. Acheson Ltd.,
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Locomotive Traversers
(ELECTRIC).
9029
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Phone—Holb. 341. Tele—Andrube, Holb., London.
Andrews & Beaumont,
(Ewart S. Andrews, B.Sc.; J. Harold Beaumont)
PATENT AGENTS, 9009
29, Southampton Buildings, London, W.C. 2.

"Spencer-Hopwood" Patent Boilers. *See page 66*
Sole Makers:
SPENCER-BONECOURT, LTD., 9095
Parliament Mansions, Victoria St., London, S.W.

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 9080
See half-page Advertisement, page 81, August 5.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 9310

University of Glasgow.

JAMES WATT CHAIRS IN THE DEPARTMENT OF ENGINEERING.

The University Court will, during the course of the University Term beginning 1st October, 1921, proceed to the APPOINTMENT of a James Watt PROFESSOR of ELECTRICAL ENGINEERING, and a James Watt PROFESSOR of the THEORY and PRACTICE of HEAT ENGINES.
Information regarding the Chairs may be obtained on application to the SECRETARY of the University Court, University of Glasgow.
19th August, 1921. R 834

Inst.C.E. Exams.—Successes

as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "J" embraces 25 years' professional experience. Address, 7434, Offices of Engineering.

Correspondence Courses for

B.Sc., Inst. C.E., I. Mech. E., all ENGINEERING EXAMS. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to Mr. TREVOR W. PHILLIPS, B.Sc. (Hons.), Assoc.M.Inst.C.E., M.R.S.I., etc., 8-10, Trafford Chambers, 59, South John Street, Liverpool. 9296

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., M.E.N., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 9049

Up-to-date Tuition for

Inst. C.E., I. Mech. E., and other Exams. by LONDON Expert, over 30 years' experience, honours, degrees, gold medals. NO FAILURES, moderate terms.—Address, R 731, Offices of Engineering.

TENDERS.

TO CONTRACTORS ONLY.

THE COMMISSIONERS OF H.M. WORKS, &c., are prepared to receive separate

Tenders before Eleven

a.m. on Friday, 16th September, 1921, for the SUPPLY of (a) ELECTRICAL and (b) MECHANICAL ENGINEERING LABOUR-IN-DAYWORK in the CARDIFF District.
Forms of Tender and all particulars may be obtained on application to the CONTRACTS BRANCH, H.M. Office of Works, King Charles Street, London, S.W. 1. R 823

North Eastern Railway.—To

BUILDERS AND IRONFOUNDERS.—The Directors are prepared to receive TENDERS for the ERECTION of ELECTRIC CAR SHEDS at South Gosforth, Newcastle-on-Tyne. Plans and Specification may be seen and Quantities and further particulars obtained upon application to Mr. Arthur Pollard, the Company's Architect, Irving House, Westgate Road, Newcastle-on-Tyne, on and after 23nd instant. Quantities supplied parties Tendering, for the whole of the works. Sealed Tenders marked "Car Sheds, South Gosforth," to be sent to the Secretary at York not later than Nine a.m., 19th September. The Directors do not bind themselves to accept the lowest or any Tender.—W. H. D. Dewey, for the Secretary. York, 18th August, 1921. R 719

COUNTY BOROUGH OF TYNEMOUTH.

Tenders are Invited for the

ERECTION of THREE REINFORCED CONCRETE JETTIES, about 51 ft. long by 62 ft. wide, upon the North Bank of the River Tyne and in the Borough of Tynemouth. The Reinforced Concrete Structure has been designed by the Firm of Messrs. The Considere Construction Co., Ltd., of 5, Victoria Street, London, S.W. 1. Drawings may be seen, and upon payment of Two Guineas, copies of the Specification and Bills of Quantities, etc., for the work may be obtained either at the Offices of the above Firm, or at the Office of the undersigned. Upon the receipt of a *bona fide* Tender the aforesaid Two Guineas will be returned. Tenders, which are to be sealed and endorsed "Tender for Jetties," are to be delivered at the Office of the undersigned, not later than 9.30 a.m. on Monday, the 19th September, 1921. No pledge is given to accept the lowest or any Tender.
JOHN F. SMILLIE,
Borough Surveyor.
Tynemouth. R 744

BURGH OF MACDUFF.

MACDUFF HARBOUR SLIPWAY.

The Macduff Town Council are prepared to receive

Tenders for the Construction

and ERECTION at Macduff of a STEEL CRADLE, TWO TRAVERSERS, and MACHINERY for the above SLIPWAY.
Copies of the Specification, Conditions, Schedule, Form of Tender, and the Drawings may be inspected at the Office of the Subscriber.
Contractors desirous of Tendering may obtain the necessary documents on payment of the sum of Two Guineas which will be returned on receipt of a *bona fide* Tender together with the documents. The copies of the Drawings are not included with these documents.
Tenders are to be lodged with the Subscriber on or before Saturday, the 3rd September, 1921.
The Town Council do not bind themselves to accept the lowest or any Tender.
ARCH. HENDERSON, M.Inst.C.E.,
21, Bridge Street,
Aberdeen. R 709

TO ELECTRICIANS AND OTHERS.

THE METROPOLITAN ASYLUMS BOARD invite

Tenders for Carrying Out

ALTERATIONS and REPAIRS to the ELECTRIC LIGHTING, FIRE ALARM and DOMESTIC BELL INSTALLATIONS at St. George's Home, Millman Street, Chelsea, in accordance with specification prepared by Mr. T. Cooper, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief.
The Specification and Form of Tender may be inspected at the Office of the Board, Embankment, E.C. 4, on and after Ten a.m., on Thursday, 25th August, and the Specification and Form of Tender can then be obtained upon payment of a deposit of £1 in respect of the work. The amount of the deposit will be returned only after the receipt of a bona-fide Tender sent in accordance with the instructions on the Form of Tender and after the Specification has been returned.
Tenders addressed as noted on the form must be delivered at the Office of the Board not later than 2.30 p.m., on Friday, 9th September, 1921.
By Order,
DUNCOMBE MANN,
Clerk to the Board. R 672

H.E.H. THE NIZAM'S GUARANTEED STATE RAILWAYS COMPANY, LIMITED.

The Board of Directors of H.E.H. The Nizam's Guaranteed State Railways Company, Limited, are prepared to receive

Tenders for the Supply of :—

(1) 13,170 STEEL RAILS, 85 lb. F.F., in lengths of 30 ft. 6 in.
841 STEEL RAILS, 85 lb. F.P., in lengths of 30 ft.
(2) 14,261 Pairs of FISH PLATES for above.
(3) 55,900 STEEL FISH BOLTS, &c., for above Rails.

For each copy of the Specification (1) or (2) a fee of 10s. will be charged, which is not returnable. Tenders, enclosed in sealed envelopes and addressed to the Chairman and Directors, and endorsed "Tender for Steel Rails," or "Tender for Fish Bolts," as the case may be, must be delivered at the Company's Offices not later than Twelve noon on 9th September, 1921.
The Directors do not bind themselves to accept the lowest or any Tender, and reserve the right to divide the order.
By Order of the Board,
W. CAREW SMYTH,
Managing Director.
Winchester House,
50, Old Broad Street,
E.C. 2.
24th August, 1921. R 868

METROPOLITAN WATER BOARD.

TENDERS FOR THE SUPPLY AND ERECTION OF PUMPING MACHINERY AT LITTLETON, MIDDLESEX.

The Metropolitan Water Board invite

Tenders for the Supply and

ERECTION of PUMPING MACHINERY, at Littleton, Middlesex, having a maximum capacity of 300 million gallons per 24 hours against a head of 46 feet.
Forms of Tender, Conditions of Contract, Specification and Drawing may be inspected without payment of fee at the Offices of the Board (Room 173) Chief Engineer's Department, Rosebery Avenue, Clerkenwell, E.C. 1, on and after Friday, 26th August, 1921.
Contractors desirous of tendering may obtain the necessary documents from Mr. Henry R. Stilgoe, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of £3 3s., which sum must be deposited with the Board's Accountant and will be returned on receipt of a *bona fide* Tender together with all incidental papers.
Such payments and applications must be made between the hours of Ten a.m. and Four p.m. (Thursdays and Saturdays excepted).
Tenders enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, E.C. 1," and endorsed "Tender for Machinery, Littleton," must be delivered at the Offices of the Board not later than Ten a.m. on Wednesday, 16th November, 1921.
The Board do not bind themselves to accept the lowest or any Tender.
W. MOON,
Clerk of the Board.
Offices of the Board,
173, Rosebery Avenue, E.C. 1.
16th August, 1921. R 797

APPOINTMENTS OPEN.

Survey Draughtsman

REQUIRED by the Government of Nigeria, for two tours, each of 12 to 18 months service with prospect of permanency. Salary £480 a year, rising by annual increments of £30 to £720 a year. Free single quarters and first class passages. Liberal leave in England on full salary.
Candidates, under 35, preferably single, must possess a knowledge of lettering, plotting co-ordinates, and map projection.—Apply at once, in writing, giving age and brief details of experience, to the Crown Agents for the Colonies, 4, Millbank, London, S.W. 1, quoting M/Nigeria, 11024. R 671

THE YORKSHIRE ELECTRIC POWER COMPANY.

Vacancy for Power Station

MAINTENANCE ENGINEER. Salary, £392 per annum. Applications should state training and experience.
Address, R 840, Offices of Engineering.

THE YORKSHIRE ELECTRIC POWER COMPANY.

VACANCY FOR RESIDENT STATION ENGINEER.

Applications are Invited for

the POST of RESIDENT STATION ENGINEER at the Company's Thornhill Power Station which will shortly become vacant. Salary, £534 per annum. Applicants must have had good practical and theoretical training.
Address, R 839, Offices of Engineering.

UNIVERSITY OF BRISTOL.

Assistant Lecturer in Engi-

NEERING, £300–£350.—For particulars and form of application, send stamped addressed foolscap envelope to the REGISTRAR, Merchant Venturers' College. R 844

CITY OF NOTTINGHAM.

Applications are Invited for

the following TEMPORARY ASSISTANTS in the City Engineer's Department; the engagement (if services are satisfactory) will be for 19 months certain.
(a) STEEL DRAUGHTSMAN. Salary, £460 per annum. Candidates must be thoroughly qualified in the design of constructional steel work, more particularly such as is required in connection with the erection of large Power Stations, &c., and similar buildings.
(b) TWO ENGINEERING ASSISTANTS. Salary, £360 per annum. Candidates must have had large and varied experience in the design of important Engineering Buildings, such as Power Stations, &c.
Applications for the above appointments will be considered only on Forms which may be obtained from the City Engineer, Guildhall, Burton Street, Nottingham, and must be sent to him, together with copies of three recent testimonials, in an envelope endorsed "Steel Draughtsman," or "Engineering Assistant" on or before 5th September, 1921.
Canvassing members of the Council is prohibited and will be a disqualification.
W. J. BOARD,
Town Clerk.
Guildhall, Nottingham,
20th August, 1921. R 838

OIL MILL ENGINEER.

Oil Millers Offer Progressive

POSITION to ENGINEER possessing highest technical qualifications, executive ability and Works experience gained in responsible position.
The Mills are extensive, equipped with modern machinery and every device for efficiency.
The power and steam are generated by the most up-to-date plant to enable maximum economy to be obtained. Intimate knowledge of modern heavy duty conveying plant is necessary.
The position is one for a man 35-40 years of age with wide experience, strong personality, tact, energy, initiative and capability of handling men and plant to the best possible advantage.
Full details, age, experience, references, etc., and salary required.
Address, R 877, Offices of Engineering.

Required by the London

CO-OPERATIVE SOCIETY, a CHIEF ENGINEER, with practical experience of Bakery, Laundry, Dairy and Refrigerating Machinery. Must also be acquainted with the running of Electric, Petrol and Steam motor vans.
Applications endorsed "Engineer" to be made by letter, stating age, salary and experience, and addressed to the General Committee, 54, Maryland Street, Stratford, London, E. 15. R 835

Competent Electrical Engineer

REQUIRED for large H.T. Power Station in the East, to take charge (under Superintendent) of entire maintenance of Switchgear, Alternators, &c. Liberal salary and allowances. Three years' agreement. Single man preferred, age not over 35.—Address, R 856, Offices of Engineering.

Electrical Engineer Required

with Rolling Mills and Blast Furnace experience. Good mechanical knowledge necessary.—Give full particulars of technical and practical experience, also state age and salary required to the Secretary, Consett Iron Co., Ltd., co. Durham. R 831

Required for China, Experi-

enced ENGINEER (Single); must be fully conversant with technical and commercial side of internal combustion engine trade (land and marine).—Address, stating experience, age and salary, R 826, Offices of Engineering.

Estimating Clerk Wanted,

must be accustomed to hydraulic and oil mill machinery.—Apply, giving full particulars of experience and stating salary required, to ROBT. MIDDLETON & CO., Sheepscar Foundry, Leeds. R 858

General Foreman Moulder

WANTED to take charge of large Iron Foundry, making castings up to 30 tons weight, comprising green and dry sand, loam moulding and coremaking. Applicants must have held similar positions of responsibility, be used to the successful control of men, and have good knowledge of up-to-date foundry practice including piecework systems. Applications, which will be treated in confidence, should state age, experience (in full), approximate salary required, and be accompanied by copies of recent testimonials. —Address, R 859, Offices of Engineering.

Experienced Mechanical

DRAUGHTSMAN, capable of taking own measurements without supervision.—Apply, stating experience, age, and salary required to DRAUGHTSMAN, Abram Lyle & Sons, Ltd., Sugar Refiners, Plaistow Wharf, Victoria Docks, E.16. R 839

Chief Draughtsman Required

for Chinese Government Railways, on three years' agreement. Salaries £500, £540 and £600 per annum. Candidates must have had previous experience in Railway Drawing Office; first-class knowledge of Steel Car Construction essential. Application, by letter only, together with particulars as to age, qualifications and physical fitness, including copies of testimonials, to K.L.M., care of J. W. Vickers & Co., Ltd., 6, Nicholas Lane, E.C. 4. R 843

Foreman Moulder Wanted for

the Loam Moulding section of large Iron Foundry. Applicants must have had first class experience in this class of moulding, and only those who have held similar position elsewhere will be considered. The position is a permanency to a suitable man.—Address in writing, stating age, experience, and salary required, R 860, Offices of Engineering.

Wanted Chief Draughtsman,

thoroughly experienced in all classes of Aerial Ropeways, must be good organiser. Good opportunity for fully qualified man. State full details of experience, age, and salary required.—Address, R 716, Offices of Engineering.

Draughtsman Wanted—

Up-to-date in colliery plant, Yorkshire District; only those giving fullest particulars, age and references entertained. No waiters need apply.—Address, R 683, Offices of Engineering.

Expert and Experienced

SALESMAN WANTED, by old established firm of Steel Manufacturers, with practical knowledge of Automobile and Tool Steels. State experience and terms, etc.—Address, R. 834, Offices of Engineering.

Foreman Moulder Required

to take control of large Plate and Machine Moulding Shop of Iron Foundry. Applications are invited from men who have specialised on moulding machines, and can prove their ability to turn out large quantities of repetition work on an economical basis. State age, experience, positions already held, and salary required.—Address, R 861, Offices of Engineering.

SITUATIONS WANTED.

Mechanical Engineer, 28,

SEEKS POST as Production Engineer, Assistant Works Manager or Jig and Tool Designer; six years' drawing office, five years' workshop experience; excellent references.—Address, R 798, Offices of Engineering.

Contractor's Engineer and

Agent (A.M.I.C.E.) with first-class training and experience Desires Post; can produce excellent references; speaks French.—Address, R 709, Offices of Engineering.

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MENT either at Home or Abroad, with Home and Colonial experience. Experienced in Electric Power Generation and Traction, Cranes, Internal Combustion Engines, Irrigation and Agricultural Machinery.
Address, R 813, Offices of Engineering.

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disengaged owing to trade depression, REQUIRES POST. Splendid technical training and varied experience in shops, drawing office, and metallurgical testing lab. Heat treatment of steel a speciality.—Address, R 853, Offices of Engineering.

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Junior Draughtsman, aged 20,

with six years' sound Mechanical and Electrical D.O. experience, WANTS POSITION in London office or works. Good Jig knowledge, quick to adapt.
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THE INTERNAL BRACING OF AEROPLANE WINGS.

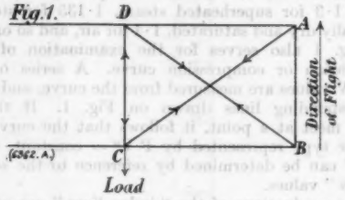
By A. H. STUART.

THE instructions issued to aeroplane riggers regarding the initial tension to be put upon the internal bracing wires of wings, have in the past been of the vaguest nature. The fact is explained by the absence of any definite information relating to the subject. The following experiments were undertaken with the view of supplying suitable data on which to base an opinion.

Consider one braced bay of a wing as shown in Fig. 1. Let A B be the root of the wing and D C the compression rib completing the first bay. When the bracing wires are fixed they will, of course, both be in tension, and these tensions will be equal when the wing is correctly trued up. The rib D C will be in compression.

During flight the drift-load will act along the rib in the direction D C, the effect being to displace the rib slightly in the direction along which the force is acting, thus reducing the tension in the bracing wire D B and increasing it in the wire C A. It is readily seen that if the drift load reaches a certain determinable amount the whole of the initial tension will be removed from D B and the tension

Fig. 1.



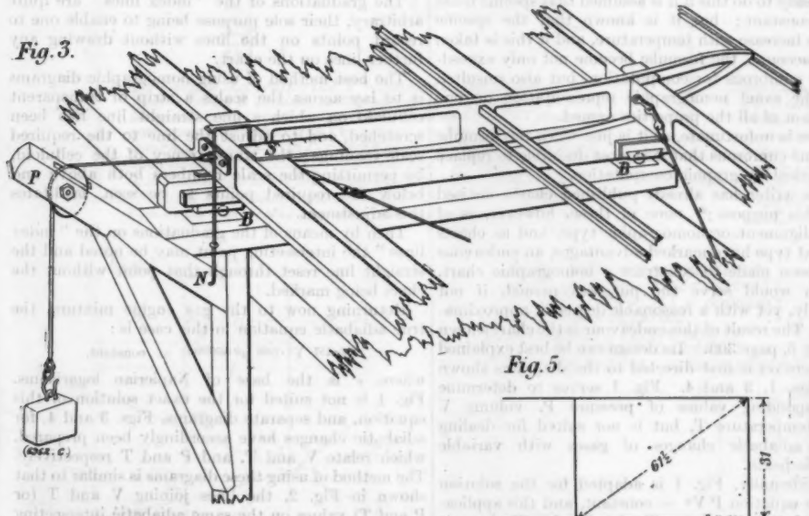


Fig. 3.

in C A will now be the drift load resolved in the direction C A, that is $\frac{C A}{C D}$ load, and will be independent of the initial tension.

For the experimental work a wing was secured in a horizontal position to a bench, by the method shown in Fig. 2, which represents the root of the wing. The compression rib which completed the first bay had a wooden fitting secured to its under surface in such a way that it could ride freely on two steel balls carried between steel plates. (See B in Fig. 3.) A piece of cable was attached to the end of the rib and passing over a pulley P terminated in a hook on which weights could be hung.

A steel needle N attached to the bench almost made contact with a millimeter scale S carried by the spar of the wing. The reading at this point gave an indication of the amount of displacement which resulted from a given load. The tension in the wires was determined with an acoustic tensiometer and, before loading, both wires were brought to the same tension.

The load was applied in small increments and the displacement as shown on the scale, and the tension in both wires were determined for each load. The results are shown in the subjoined Table.

The readings were not continued farther as the tension in the anti-drift wire had become too low to measure with accuracy. Fig. 4 shows the results expressed graphically. It will be seen that the points lie very well about two straight lines. If the lower of these graphs (representing the readings taken on the anti-drift wire) be produced to a point at which the tension is zero, as shown by the dotted portion in Fig. 4, a load of 160 lb. is indicated. If the upper graph be produced to the same load it represents a tension of 312 lb. in the drift wire. The

Fig. 2.

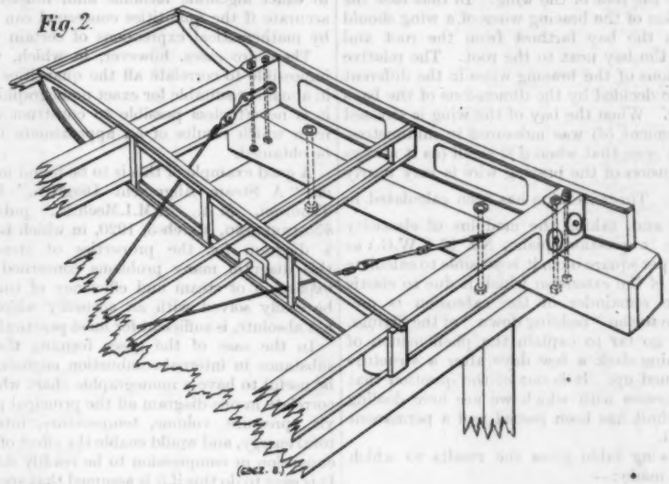
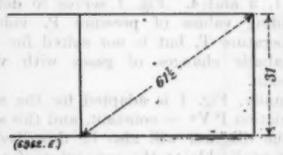


Fig. 5.



experiments indicate, therefore, that in a bay of these dimensions with an initial tension in both wires of 160 lb., it requires a load in drift of 160 lb. to remove all tension from the anti-drift wire and under

Loads in Pounds.	Displacement.	Tension in Pounds.	
	In Millimetres.	Drift Wire.	Anti-Drift Wire.
0	0·0	160	160
21	1·5	180	140
40	3·2	200	125
60	5·1	215	105
70	6·0	225	95
80	6·8	225	90
90	7·8	235	75
100	8·2	250	60
110	9·1	265	—

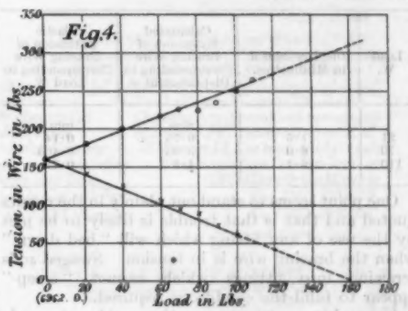
these conditions the tension in the drift wire is 312 lb. Referring to the dimensions of the bay shown in Fig. 5 and neglecting the effects of offset (the error introduced thereby being negligible, see Air Board C.I.M. No. 32, July, 1917), it will be seen that the tension in the drift wire, when the anti-drift wire loses its tension, should be:

$\frac{61\frac{1}{2}}{31}$ of 160 = 317 lbs.

It would appear, therefore, that our consideration of the simple bay in Fig. 1 is fully upheld by experiment. This being so, it may be stated generally that if:

L = length of bracing wire.
D = depth of bay of wing.
W = load on compression rib due to maximum drift,

Fig. 4.



the initial tension T on the bracing wires is given by:

$$T = \frac{L W}{2 D}$$

and when the drift load comes into play the tension in the anti-drift wire becomes zero, and that in the drift wire becomes $\frac{L W}{D}$.

These would appear to be the best conditions of bracing. We will now consider experimental results showing the effects produced by initial tensions other than those given above.

Case I.—Initial tension in both wires 100 lb. Drift load 110 lb.

Results:—Tension in drift wire 220 lb.
Tension in anti-drift wire, zero.
Displacement, 11·5 mm.

Case II.—Both wires initially slack. Drift load 110 lb.

Results:—Tension in drift wire, 220 lb.
Anti-drift wire, very slack.
Displacement, 14·5 mm.

Case III.—Initial tension in both wires 290 lb. Drift load 110 lb.

Results:—Tension in drift wire, 370 lb.
Tension in anti-drift wire, 165 lb.
Displacement 8 mm.

Now adopting the formula given above, the initial tension for a drift load of 110 lb. should be:

$$T = \frac{L W}{2 D} = \frac{61\frac{1}{2} \times 110}{2 \times 31} = 109 \text{ lbs.}$$

and the final tension of the drift wire would then be

$$\frac{L W}{D} = \frac{61\frac{1}{2} \times 110}{31} = 218$$

It will be seen, therefore, that in cases I and II

the initial tension was too low and this resulted in a greater displacement of the wing, and no reduction in the final tension in the drift wire. In case III the initial tension was too high, and although the displacement was not materially diminished, the final tension in the drift wire was excessive.

The data given above refer to one bay of a wing only. In the case of a complete wing the problem appears to be similar to that of a braced cantilever, with uniform loading, *i.e.*, the load which a drift wire will have to carry will be greater as the bay is nearer to the root of the wing. In that case the initial tension of the bracing wires of a wing should be least in the bay farthest from the root and greatest in the bay next to the root. The relative initial tensions of the bracing wires in the different bays will be decided by the dimensions of the bays in the wing. When the bay of the wing is stressed the displacement (d) was measured in millimetres. It is readily seen that when d is small (as it always is) the extension of the bracing wire is very nearly equal to $\frac{d}{2}$. This extension has been calculated in three cases and, taking the modulus of elasticity for the wire in question (piano, No. 12 S.W.G.) as 11,600 tons per square inch, it is possible to calculate the portion of the extension which is due to elastic strain. The remainder of the extension is presumably due to the "bedding down" of the fittings. This would go far to explain the phenomenon of wires becoming slack a few days after a structure has been trued up. It is out of the question that with the stresses with which we are here dealing the elastic limit has been passed and a permanent set produced.

The following table gives the results to which reference is made:—

Load W.	Displacement d in Millimetres.	Calculated Extension of Bracing Wire Corresponding to Displacement d.	Elastic Extension of Bracing Wire Corresponding to Load W.
		mm.	mm.
21	1·5	0·75	0·14
70	6·0	3·05	0·465
110	9·1	4·6	0·75

One point seems to stand out plainly in the results quoted and that is that trouble is likely to be met by the use of any fitting which will "bed down" when the bracing wire is in tension. Swaged rods screwing into fittings which cannot "creep" appear to fulfil the conditions required.

In machines with stagger the problem is made rather more complex by the oblique thrust of the interplane struts, but in every case the data exist for the calculation of the magnitude and distribution of the drift forces. That being so the determination of the most suitable initial tension in the internal bracing wires should present little difficulty.

It is not suggested that the most suitable initial tension should be recorded to the nearest pound. It would be sufficient for all practical purposes if the tensions were given to the nearest 50 lb., or in those of higher magnitude to the nearest 100 lb. The tension should thus be given in "round numbers."

When this part of the problem has been solved it will be time to consider how best to measure the tension in a bracing wire. There is little doubt that once the range of magnitude and conditions of measurement have been determined the design of a suitable tautness meter will be possible.

New British Chamber of Commerce in Mexico City.—It has been felt for some time that it was to the detriment of British interests in Mexico that there should be no British Chamber of Commerce in the Republic, especially in view of the well-established and efficient Chambers of Commerce of the American, Belgian, Italian and Dutch colonies. During the war the British Trade Board (Mexico) was organised by British firms and residents in Mexico City to protect and assist British interests in Mexico, acting under the tutelage of H.M. Legation. It has now been decided that this body should cease to function and that its place should be taken by a Central British Chamber of Commerce acting independently of the Legation. Advice has now reached the Federation of British Industries that the Chamber has been legally registered, and copies of the deeds of organisation and bye-laws have been received. Particulars as to conditions of membership, etc., can be obtained from the North American section of the F.B.I. Overseas Organisation at the Head Office, 39, St. James Street, London, S.W.1.

A NOMOGRAPHIC CHART FOR GASES.

By T. B. Morley, D.Sc., M.I.Mech.E.

In recent years there have been many useful applications of the principles of nomography, in the construction of diagrams—sometimes termed "alignment charts"—by means of which the numerical calculation of formulæ is avoided and the desired results obtained from the diagram very easily and quickly, and with less liability to mistakes.

These diagrams are usually designed to correspond to exact algebraic formulæ and, indeed, are only accurate if the quantities concerned can be related by mathematical expressions of certain types.

There are cases, however, in which, while it is impossible to correlate all the quantities concerned in a manner suitable for exact nomographic plotting, it is nevertheless possible to construct a diagram from which results of an approximate nature can be obtained.

A good example of this is to be found in an article on "A Steam Alignment Diagram," by D. H. Thomson, M.A., A.M.I.Mech.E., published in Engineering, March 5, 1920, in which is described a diagram for the properties of steam. From this diagram many problems concerned with the expansion of steam and efficiency of turbines can be easily solved with an accuracy which, though not absolute, is sufficient for most practical purposes.

In the case of the gases forming the working substance in internal-combustion engines, it would be useful to have a nomographic chart which would correlate in one diagram all the principal properties, viz., pressure, volume, temperature, intrinsic and total energy, and would enable the effect of adiabatic expansion or compression to be readily determined. It is easy to do this if it is assumed that specific heats are constant; but it is known that the specific heats increase with temperature, and if this is taken into account, the formulæ become not only exceedingly cumbrous for computation, but also unsuited for the exact nomographic representation on one diagram of all the properties named.

This is unfortunate, as it is just when the formulæ become cumbrous that it is most desirable to replace numerical by graphic computation.

The writer has already published charts devised for this purpose;* none of these, however, is of the alignment or nomographic type, and as charts of that type have marked advantages, an endeavour has been made to construct a nomographic chart, which would serve the purposes named, if not exactly, yet with a reasonable degree of approximation. The result of this endeavour is the chart shown in Fig. 5, page 303. Its design can be best explained if attention is first directed to the diagrams shown in Figs. 1, 3 and 4. Fig. 1 serves to determine corresponding values of pressure P, volume V and temperature T, but is not suited for dealing with adiabatic changes of gases with variable specific heats.

Incidentally, Fig. 1 is adapted for the solution of the equation $P V^n$ = constant, and this application of the diagram will also be described as it renders it applicable to the expansion of any gas or vapour following this law, "n" being appropriately chosen.

For the gases in an internal-combustion engine, typical constants† are

$$K_p = 317 + 0{\cdot}0623\ T \text{ ft. lb. per lb. per deg. C.}$$

and

$$K_v = 220 + 0{\cdot}0623\ T \text{ ft. lb. per lb. per deg. C.}$$

or, expressed in heat units (Centigrade)

$$K_p = 0{\cdot}2265 + 0{\cdot}0000445\ T$$
$$K_v = 0{\cdot}157 + 0{\cdot}0000445\ T$$

From the above the characteristic gas equation $P V = R T$ becomes $P V = 0{\cdot}676\ T$, where P is in pounds per square inch, V in cubic feet per pound and T in degrees Centigrade absolute.

A straight line laid across Fig. 1—the construction of which diagram is described in the appendix—cuts the scales of P, V and T at values connected by this equation.

For a gas with a different value of R, the scale of T need only be slightly displaced bodily along its axis. For example, to adapt Fig. 1 for air, the T scale need only be displaced upwards by an amount equal to $\frac{1}{120}$ of the distance on the T scale representing a temperature ratio of 10. Thus if the ratio 10 : 1 on the scale of T is represented by 30 cm., the displacement required to adapt the diagram for air is 2·5 mm.

To determine the result of changes following the law $P V^n$ = constant, a line joining the given initial values of P and V is laid down and its point of intersection A (see Fig. 2) with the vertical line marked with the appropriate index "n" is noted. Then any straight line through A will cut the scales at values corresponding to the equation, *i.e.*, in Fig. 2, $P_1 V_1^n = P_2 V_2^n = P_0 V_0^n$.

The same lines determine also the corresponding temperatures, thus solving the equations $T V^{n-1}$ = constant, and $T P^{\frac{n-1}{n}}$ = constant.

It should be noted that the *ratios* of temperatures $\frac{T_1}{T_0}, \frac{T_2}{T_0}$ &c., are unaffected by displacement of the T scale along its axis, so that, for ratios only, the same T scale may be used for air or any other gas.

The vertical "index lines" are drawn on Fig. 1, for the values of "n" most frequently required, *e.g.*, 1·3 for superheated steam, 1·135 for steam initially dry and saturated, 1·4 for air, and so on.

Fig. 1 also serves for the examination of an expansion or compression curve. A series of P and V values are measured from the curve, and the corresponding lines drawn on Fig. 1. If these lines meet at a point, it follows that the curve is of the type represented by $P V^n$ = constant, and "n" can be determined by reference to the scale of "n" values.

The graduations of the "index lines" are quite arbitrary, their sole purpose being to enable one to record points on the lines without drawing any further lines on the chart.

The best method of using nomographic diagrams is to lay across the scales a strip of transparent celluloid on which a fine straight line has been scratched, and to adjust the line to the required scale readings; the transparency of the celluloid, by permitting the scale numbers both above and below the required points to be seen, facilitates this adjustment.

Then by means of the graduations on the "index lines" the intersecting point may be noted and the straight line reset through that point without the chart being marked.

Returning now to the gas engine mixture, the true adiabatic equation in this case is:

$$p_{0\cdot157}\ v_{0\cdot2265}\ e^{0\cdot0000445\,t} = \text{constant.}$$

where e is the base of Napierian logarithms. Fig. 1 is not suited for the exact solution of this equation, and separate diagrams, Figs. 3 and 4, for adiabatic changes have accordingly been prepared, which relate V and T, and P and T respectively. The method of using these diagrams is similar to that shown in Fig. 2, the lines joining V and T (or P and T) values on the same adiabatic intersecting at a point on the intermediate vertical "ϕ" scale. The "ϕ" scale is uniform, and as a matter of fact represents entropy, the values of which may occasionally—though rarely—be required, the scale being graduated chiefly for the reason already mentioned in the case of the index lines on Fig. 1.

The method of constructing Figs. 3 and 4 is given in the appendix. The intrinsic energy I in thermal units per pound of gas = $0{\cdot}157\ T + 0{\cdot}00002225\ T^2$, and is shown in Fig. 3 by a scale marked off along the same axis as the T scale. The total energy $E = I + \frac{PV}{J} = 0{\cdot}2265\ T + 0{\cdot}00002225\ T^2$, and is shown in a similar manner on Fig. 4.

By means of any two of the three diagrams, Figs. 1, 3 and 4—preferably Figs. 1 and 3, or 1 and 4—calculations on ideal internal-combustion cycles may now be carried out, the values of P, V, T, I (and E also if required) for all the required points in the cycle being easily obtained from the diagrams.

As an example, take the case of a gas engine cycle of the ordinary constant-volume type. At the beginning of compression let $P_1 = 14{\cdot}7$, and $T_1 = 386$.

From Fig. 1, $V_1 = 18$, and from Fig. 3, I_1 at

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* Engineering, October 3, 1913, page 445, and Dec. 18, 1914, page 734, also *Journ. Inst. Mech. E.*, Dec., 1920.

† These constants are given by W. J. Walker, Ph.D., in *Journal Inst. Mech. Engineers*, Dec. 1920.

386 deg. C. absolute is read as 64. Let the compression ratio be 5·4, so that V_2 at the end of compression = 3·33. From Fig. 3 by following the method indicated, T_2 at the end of the adiabatic compression is found to be 745, and hence $I_2 = 129$.

By laying a straight line on Fig. 1, from $T_2 = 745$ to $V_2 = 3·33$, P_2 is found to be 152.

P could also be found from Fig. 4 by joining, $T_2 = 745$ to the point where the ϕ axis is cut by the line representing $P_1 = 14·7$ and $T_1 = 386$.

Let the heat added to the working substance during the constant volume explosion be 401 units, hence at the beginning of expansion $I_3 = 129 + 401 = 530$, and the corresponding value of T_3 from Fig. 3 is 2,500. V_3 is still 3·33 and, from Fig. 1, P_3 is determined as 515. Adiabatic expansion to $V_4 = 18$ now takes place and from Fig. 3 $T_4 = 1{,}545$, $I_4 = 295$ and from Fig. 1 (or Fig. 4) $P_4 = 58$.

The heat supplied during the cycle = 401 units, that rejected = 295 − 64 = 231, so that the heat converted into work = 170 units and the thermal efficiency is $\frac{170}{401}$ = 42·4 per cent.

The mean effective pressure is work done (in work units) divided by stroke volume = $\frac{170 \times 1400}{144 \times (18 - 3·33)}$ = 113 pounds per square inch. The "air standard" efficiency is 49·1 per cent. and the mean effective pressure (for the same heat added) is 131.

As an example of a Diesel engine cycle, beginning with the same P_1, V_1 and T_1 as above, let the compression ratio be 14·3 so that V_2 becomes 1·26,

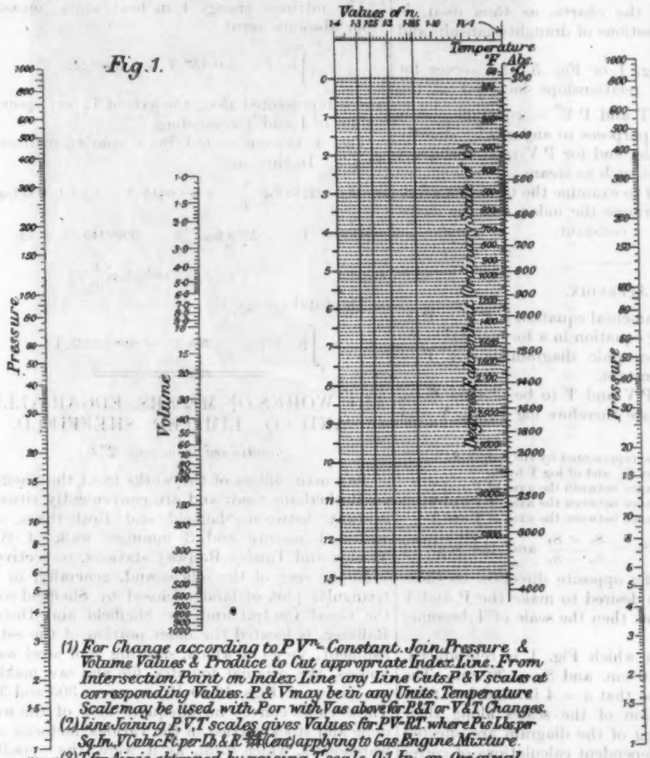


Fig. 1.

(1) For Change according to PV^n = Constant. Join Pressure & Volume Values & Produce to Cut appropriate Index Line. From Intersection Point on Index Line any Line Cuts P & V scales at corresponding Values. P & V may be in any Units. Temperature Scale may be used with P or with V as above for P&T or V&T Changes.
(2) Line Joining P, V, T scales gives Values for PV=RT. where P is Lbs per Sq. In., V Cubic Ft. per Lb. & R. 96 (Cent.) applying to Gas Engine Mixture.
(3) T for Air is obtained by raising T scale 0·1 In. on Original Full Scale Chart; this reproduction is ¾ that Scale

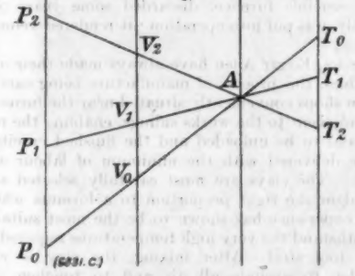


Fig. 2.

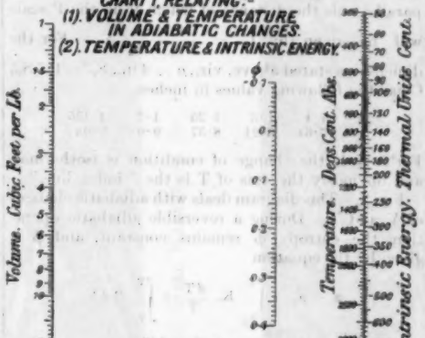


Fig. 3. GAS ENGINE MIXTURE.
CONSTANTS. $K_P = ·2265 + ·0000445\,T.$
$K_V = ·157 + ·0000445\,T.$
CHART 1, RELATING:-
(1). VOLUME & TEMPERATURE IN ADIABATIC CHANGES.
(2). TEMPERATURE & INTRINSIC ENERGY.

To use:- for Adiabatic Changes:- Join Initial Volume & Temperature Values. Final Values lie on Line Cutting Middle Vertical at same Point.

and assume combustion at constant pressure and that the volume V_3 at the end of combustion is 1·96.

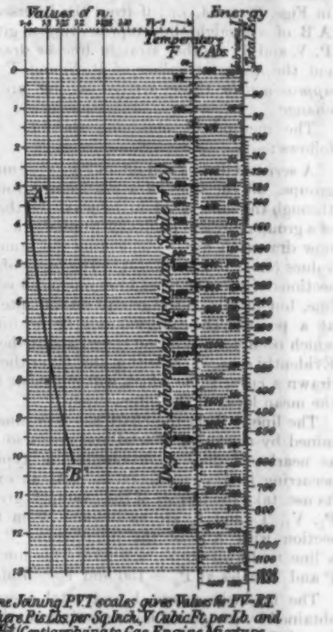
—	P.	V.	T.	Intrinsic Energy I.	Total Energy E.
(1) At beginning of compression	14·7	18	386	64	
(2) At end of compression	570	1·26	1045	189	262
(3) At end of combustion	570	1·96	1630	315	430
(4) At end of expansion	29·5	18	780	136	

The conditions at the various points of the cycle, as determined from the charts, are as follows:—

Measuring both heat and work in heat units, we have work done in compression = $I_2 - I_1 = 125$. Work done during combustion

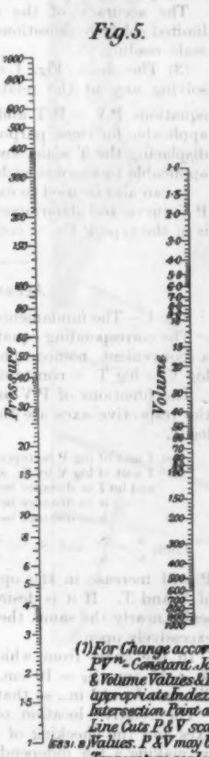
$$= \frac{570 \times (1·96 - 1·26) \times 144}{1400} = 41$$

Heat added during combustion = $41 + (I_3 - I_2)$



(2) Line Joining P.V.T scales gives Values for PV=RT. where P is Lbs per Sq. Inch, V Cubic Ft. per Lb. and R=96 (Cent) applying to Gas Engine Mixture.
(3) T for Air is obtained by raising T scale 0·1 In.*
(4) For Gas Engine Mixtures, Adiabatic Changes are determined approximately by Lines of P.V.T. intersecting on A. B.
(5) Energy I & E is obtained by (right) Horizontals from T scale to scale at (2) (4) I, E are for Gas Mixtures, for which $K_P = ·2265 + ·0000445\,T.$ $K_V = ·157 + ·0000445\,T.$
(* on original Scale)

Fig. 5.



(1) For Change according to PV^n = Constant. Join Pressure & Volume Values & Produce to Cut appropriate Index Line. From Intersection Point on Index Line any Line Cuts P & V scales at corresponding Values. P & V may be in any Units. Temperature scale may be used with P or with V as above for P&T or V&T Changes.

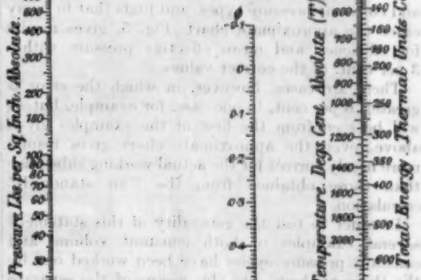


Fig. 4. GAS ENGINE MIXTURE.
CONSTANTS. $K_P = ·2265 + ·0000445\,T.$
$K_V = ·157 + ·0000445\,T.$
CHART 2. RELATING:-
(1). PRESSURE & TEMPERATURE IN ADIABATIC CHANGES.
(2). TEMPERATURE & TOTAL ENERGY.

To use:- for Adiabatic Changes:- Join Initial Pressure & Temperature Values. Final Values lie on Line Cutting Middle Vertical at same Point.

= 167. (Alternatively = $E_2 - E_2 = 168$, practically agreeing.)

Work done in expansion = $I_3 - I_4 = 179$.

Heat rejected = $I_4 - I_1 = 72$.

From these the work done in the cycle = 41 + 179 − 125 = 95.

The thermal efficiency = $\frac{95}{167}$ = 57 per cent., and the mean effective pressure = $\frac{95 \times 1400}{144\,(18 - 1·26)}$

= 55·1 lb. per square inch. The construction of a single chart, combining the functions of Figs. 1, 3 and 4, though representing adiabatic changes only approximately, may now be described.

The chart is shown in Fig. 5, which is simply Fig. 1 with the addition of a curved line A B and scales of intrinsic and total energy placed alongside the temperature scale. In Fig. 5, the line A B fulfils the same function as the vertical ϕ lines in Figs. 3 and 4, *i.e.*, if from the intersection with A B of a straight line representing a given initial P, V and T, another straight line be drawn, it will cut the scales at values of P, V and T which are *approximately* those arrived at by an adiabatic change.

The method of obtaining the line A B is as follows :—

A series of lines is laid off on Fig. 3 (or on Fig. 4) in groups, all the lines of a particular group passing through the same point on the ϕ axis, so that the lines of a group represent points on an adiabatic. Lines are now drawn on Fig. 5 connecting the same V and T values (or P and T values). The locus of the intersections of the groups of lines on Fig. 3 is a vertical line, but on Fig. 5 the groups do not intersect each at a point. The intersections lie within a band which occupies a position round about the line A B. Evidently somewhere within this band there may be drawn a curved line which will represent fairly well the mean locus of the intersections.

The line A B on the chart has been finally determined by a process of trial and error, so as to suit as nearly as may be a number of typical cases occurring in gas engine cycles. As an example of its use, take the former of the examples given above. P_1, V_1, T_1 and I_1 are as before; from the intersection with A B of the line joining P_1, V_1, T_1, a line is drawn to $V_2 = 3·33$. This line cuts the P and T scales at $P_2 = 150$ and $T_2 = 736$.

The intrinsic energy I and total energy E are obtained by projecting horizontally from the T scale. $I_2 = 127$. Adding 401 for the heat added during explosion as before, $I_3 = 528$, from which $T_3 = 2{,}490$. V_3 remaining 3·33, join this point on the V scale to T = 2,490. The line determines $P_3 = 510$. From its intersection with A B, draw a line to $V_4 = 18$, and so determine P_4 and T_4, which are found to be 57 and 1,530 respectively. By projecting from $T_4 = 1{,}530$, I_4 is found to be 292.

These values are in fair agreement with those previously obtained. The efficiency as calculated from them is 42·9 per cent., and the mean effective pressure is 115, as against the previously-determined values 42·4 and 113.

The writer has tested the charts by a number of cases of typical cycles, of both constant volume and constant pressure types, and finds that in many cases the approximate chart, Fig. 5, gives results for efficiency and mean effective pressure within 3 per cent. of the correct values.

There are cases, however, in which the error is greater, 6 per cent. in one case, for example, but as will be seen from the first of the examples given above, even the approximate chart gives results more nearly correct for the actual working substance than those obtained from the "air standard" calculation.

In order to test the generality of this statement several examples of both constant volume and constant pressure cycles have been worked out by the three methods, viz., by means of the separate diagrams as described above, by means of the approximate chart, and by calculation of the "air standard" cycle. For any cycle, the compression ratio and the amount of heat developed in combustion have been taken as the same in each method of calculation (the maximum pressures and temperatures thus differ, the "air standard" temperatures being higher owing to the lower average specific heat).

It was found, that in all the cases examined, even the approximate chart gave more correct results than the "air standard" values.

In conclusion, the writer would sum up as follows the results of his examination of the diagrams described :—

(1) A chart, Fig. 5, can be drawn which is serviceable for evaluating with ease and rapidity internal-combustion engine cycles, and which yields results, which though approximate only, are preferable to the "air standard" values.

(2) For greater accuracy in internal-combustion engine calculations, the separate charts, Figs. 5 (neglecting the line A B) and Fig. 3 or Fig. 4, should be used. As compared with numerical computation, there will still be great advantages in respect of ease, speed and freedom from mistakes.

The accuracy of the charts, as thus used, is limited solely by questions of draughtsmanship and scale reading.

(3) The chart, Fig. 1 or Fig. 5, also serves for solving any of the relationships included in the equations $PV = RT$ and $PV^n = \text{constant}$; it is applicable for these purposes to any gas by slightly displacing the T scale, and for P V relationships is applicable to vapours such as steam.

It can also be used to examine the type of a given P V curve and determine the index n if the curve is of the type $PV^n = \text{constant}$.

Appendix.

Fig. 1.—The fundamental equation is $PV = RT$. The corresponding equation in a form suitable for a convenient nomographic diagram is $\log P + \log V - \log T = \text{constant}$.

The functions of P V and T to be plotted along the respective axes are therefore log P, log V and log T.

Let 1 unit of log P be represented by the length S_P,
1 unit of log V by S_V, and of log T by S_T
and let l = distance between the axes of P and T
a = distance between the axes of P and V
b = distance between the axes of V and T

Then $\frac{a}{b} = \frac{S_P}{S_T}$ and $S_V = \frac{S_P \times S_T}{S_P + S_T}$ and the scale of P will increase in the opposite direction to those of V and T. If it is desired to make the P and V scales nearly the same, then the scale of T becomes excessively open.

In the chart from which Fig. 1 is reproduced, $S_P = 15$ cm., $S_V = 10$ cm. and $S_T = 30$ cm. The distance $l = 12$ in., so that $a = 4$ in. and $b = 8$ in.

The relative location of the scales along their axes and the checking of the diagram are effected by making a few independent calculations of corresponding P, V and T values and seeing that these values on the axes are collinear.

For the location of the "index lines" for $PV^n = \text{constant}$, since $\log P_1 + n \log V_1 = \log P_2 + n \log V_2$, it follows that the intersection of lines drawn through P_1, V_1, and P_2, V_2, will lie on a parallel axis the distance of which from the P scale will be given by $C = \frac{n \times S_P}{n S_P - S_V} a$. For the dimensions stated above, viz., $a = 4$ in., $S_P = 1·5 S_V$, C has the following values in inches,

n	1·4	1·3	1·25	1·2	1·135
c	7·64	8·21	8·57	9·0	9·68

For $n = 1$, the change of condition is isothermal, and obviously the axis of T is the "index line."

Fig. 3.—This diagram deals with adiabatic changes of V and T. During a reversible adiabatic operation, the entropy ϕ remains constant, and ϕ is given by the equation

$$\phi - \phi_0 = \int_{T_0}^{T} K_v \frac{dT}{T} + \int_{T_0}^{T} P\,dV$$

which becomes, in terms of V and T,

$$\phi - \phi_0 = 0·157 \log_e \frac{T}{T_0} + 0·0000445 (T - T_0) + 0·0695 \log_e \frac{V}{V_0}$$

or $$f(\phi) = f(T) + f(V)$$

where $$f(T) = 0·157 \log_e \frac{T}{T_0} + 0·0000445 (T - T_0)$$

and $$f(V) = 0·0695 \log_e \frac{V}{V_0}$$

This equation is suited for simple nomographic representation.

The nomogram differs from Fig. 1 in that along the axis of T is plotted, not log T, but $f(T)$ as above. The scale of V, as before, is logarithmic.

In the original of Fig. 3, the volume ratio 10 : 1 (or $\log_{10} \frac{V}{V_0} = 1$) is represented by 20 cm., hence 1 unit of $f(V) = \frac{20}{0·0695 \log_e 10} = 125$ cms.

One unit of $f(T) = 50$ cm. The axis of ϕ divides the distance between the V and T axes in the ratio 125 : 50. The unit of $f(\phi)$—which is simply ϕ—is represented by $\frac{50 \times 125}{50 + 175} = 35·71$ cm.

The intrinsic energy I in heat units (measured from absolute zero) =

$$\int K_v\,dT = 0·157\ T + 0·00002225\ T^2$$

and is represented along the axis of T, corresponding values of I and T coinciding.

Fig. 4 is constructed in a similar manner to Fig. 3. In this case

$$\phi - \phi_0 = 0·2265 \log_e \frac{T}{T_0} + 0·0000445 (T - T_0) - 0·0695 \log_e \frac{P}{P_0}$$

so that $$f(T) = ·2265 \log_e \frac{T}{T_0} + ·0000445 (T - T_0)$$

and $$f(P) = - ·0695 \log_e \frac{P}{P_0}$$

The total energy E

$$= \int K_p\,dT = ·2265\ T + ·00002225\ T^2$$

THE WORKS OF MESSRS. EDGAR ALLEN AND CO., LIMITED, SHEFFIELD.

(*Continued from page* 274.)

The main offices of the works front the Sheffield to Rotherham road, and are conveniently situated midway between Sheffield and Rotherham, and within 1 minute and 3 minutes' walk of West Tinsley and Tinsley Railway stations, respectively.

In the rear of the offices and, generally, in the triangular plot of land enclosed by Sheffield-road, the Great Central and the Sheffield and District Railway, is located the older portion of the establishment, views of which, showing tool steel warehouses, the original foundry, file and saw making, are given in Figs. 12 to 19, on pages 305 and 306. These views convey no adequate idea of the work done and stock carried in the various factories and warehouses, which form, as it were, the "cradle" of the company. In the first place may be mentioned the tool steel melting department. This is equipped with a Robinson and Dawson gas-fired regenerative six-chamber crucible furnace with a capacity of thirty ½-cwt. crucibles, also two Siemens' new-form, gas-fired regenerative crucible furnaces, having a capacity of twelve ½-cwt. crucibles each. Such was the demand for the firm's special steel during the period of the war that a 12-hole coke-fired crucible furnace, discarded some years previously, was put into operation · it rendered yeoman service.

Messrs. Edgar Allen have always made their own crucibles, the process of manufacture being carried out in shops conveniently situated near the furnaces and adjacent to the works sidings, enabling the raw material to be unloaded and the finished crucibles to be delivered with the minimum of labour and delay. The clays are most carefully selected and mixed in the right proportion to a formula which long experience has shown to be the most suitable to withstand the very high temperatures required to melt tool steel. After mixing, the clay is well trodden to exclude all air and to toughen the mixture. The clay is then moulded under a press to the desired shape, and the crucibles are afterwards carefully dried in specially-designed drying chambers. When dried, the crucibles together with the lids are removed to shelves fixed up on the walls of the furnace house and just before use they are carefully annealed in muffle furnaces built for this special purpose on the crucible furnace charging platform.

After melting and having had the necessary "physic" added in the form of various alloys required for the special quality of tool steels manufactured at the Imperial Works, the liquid steel is teemed into ingot moulds and when cool the cast ingots are removed to the ingot warehouse for inspection. All defects are marked and afterwards carefully removed either by pneumatic chipping

THE WORKS OF MESSRS. EDGAR ALLEN AND CO., LIMITED, SHEFFIELD.

Fig. 12. Tool Steel Warehouse No. 1.

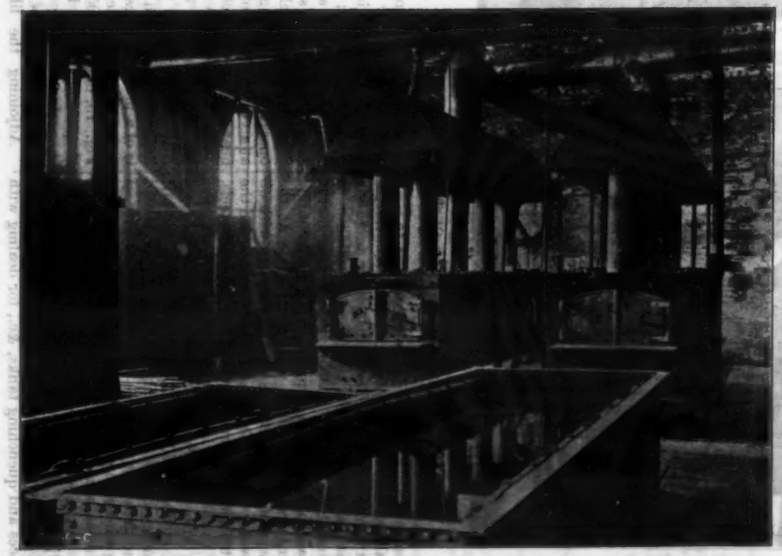


Fig. 13. Tool Steel Warehouse No. 4: Heat Treatment Plant.

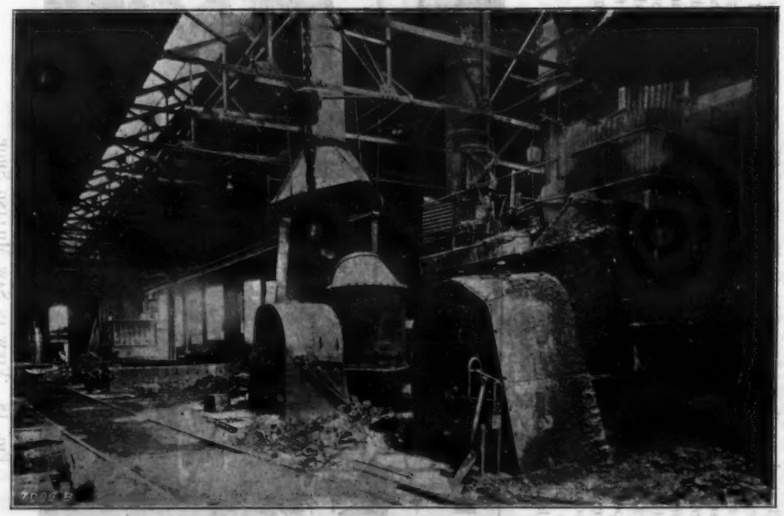


Fig. 14. Foundry for Tramway Track Work.

Fig. 15. Corner of File-Cutting Shop.

hammers or by grinding as circumstances dictate. The prepared ingots are then loaded on to the firm's steam lorries and dispatched to Park View Forge, which the company own at Owlerton, a distance of 5 miles from the Imperial Steel Works, or in some cases to the rolling mills. The ingots are there forged or rolled out into the finished bars of tool steel. On return to the steel warehouse the bars are again inspected, annealed and in some cases reeled, painted, labelled and stocked ready for delivery. These processes are carried out in five large warehouses of a total floor area of 3,736 square yards.

Warehouses Nos. 1 to 3 are utilised for inspection, grinding, chipping, reeling and storing the smaller sections of finished bars; and warehouses 4 to 5 for annealing, heat treatment and storing the larger varieties of tool steel. The furnaces for annealing the bars as received from the forge or rolling mills are suitably grouped in No. 4 steel warehouse, and are of a modern type, fitted with recording pyrometers and supplied with town gas. At the east end of this warehouse are the furnaces with oil and water quenching tanks, oil cooler, &c., for the heat treatment of special motor and air-craft steels. This installation is most complete and was put down during the war to deal especially with the large and continuous demand for Allen's special aircraft and motor lorry steel. Very special attention is paid to the treatment of this steel, the entire process being under the supervision of the works' chemist and his assistants. Figs. 12 and 13 on page 305 are views in the warehouses No. 1 and No. 4.

Adjacent to and opening into No. 4 warehouse is the hardening shop, which is fitted up with furnaces and quenching tanks, &c., for dealing with the hardening of tools, gear wheels, and other similar work.

Crossing the yard from No. 3 steel warehouse are the shops of the file department, in which files of all shapes and classes are made and cut, from the roughest cut rasp down to the smallest jeweller's or dentist's file. In passing, it should be mentioned that with a view to giving employment to a number of families who for generations past have been connected with the Edgar Allen establishment, some of the fine cutting of the small special files is done by hand by outside labour. The file department at the works is run entirely by machinery.

The bars, as received from the forge and rolling mills, are cut to length, and the blanks forged under special forging hammers to the required shape, and afterwards carefully annealed in gas-fired annealing furnaces. The forgings are then wet ground true, ready for cutting; flat files by semi-automatic grinding machinery and the round, half-round, three square and special shapes, and odd lots, by hand. Semi-automatic machinery is employed in the actual operation of cutting, the process being performed at a very high rate of speed. When cut the files are heated to the desired temperature for hardening in a lead bath furnace heated by low-pressure air and gas and afterwards quenched in a salt water bath. After being cleaned the files are sent into the warehouse for inspection and packing. This inspection is of a most rigid description, and any file discovered to be in any way defective is immediately rejected. Fig. 15, on page 305, is a view in the file cutting shop; whilst Figs. 16 and 17, on the present page, show the hardening of files in a salt bath and the hand cutting of files.

Adjoining the file department are the shops of the saw department, in which is installed machinery for the manufacture of circular saws up to 86 in. in diameter. The saw plates rolled out of ingots of special steel, made at the Imperial Works, are first pared under a special shears to roughly the outside diameter of the proposed saw, the teeth are then milled out to the required pitch and shape; in the case of saws of large teeth and pitch the spaces between the teeth are first punched out and afterwards milled and ground to proper size and shape. After cutting, the saws are heated in special furnaces and quenched in oil, sent into the straightening shop, and afterwards ground and polished. A view in the saw milling shop is reproduced in Fig. 18 subjoined.

Fig. 16. Hardening Files in a Salt Water Bath.

Fig. 18. View in Saw Milling Shop.

Fig. 17. The Hand Cutting of Files.

Fig. 19. Charging Crucible Furnaces.

In the straightening shop, circular saws which have warped or buckled by injudicious treatment at the hands of users, and saws which require to be straightened or flattened between the various phases of manufacture are treated by hammering with specially-shaped hammers on an anvil. Very great skill and experience are required for this class of work, and Messrs. Edgar Allen are justly proud of their skilled workmen in this shop.

Leaving the saw department, and passing down the yard through No. 5 steel warehouse, in an easterly direction, the original foundry buildings are on the left-hand. These buildings have been converted into a press and forge shop, and they contain a 500-ton steam hydraulic press made by Messrs. Davy Brothers, Limited, used for a large variety of general forging work. This shop is well-equipped with continuous and re-heating furnaces, and overhead electric cranes. It contains also a 30-cwt. duplex Tropenas melting plant. This melting plant was formerly used for foundry purposes, but since the

putting down of the extensive new foundry on the opposite side of Sheffield-road—with which we shall deal in our concluding article—it has been used in conjunction with the forge and press department.

Leaving the forge and press department, in an easterly direction and towards the apex of the triangle is situated No. 2 foundry. This foundry, a view of which is given in Fig. 14 on page 305, is set apart solely for the manufacture of manganese steel tramway points and crossings, and is equipped with a specially-designed melting plant to carry out this work, for which Messrs. Edgar Allen and Co. enjoy a high reputation amongst tramway authorities, both in this country and abroad. The shop is fully equipped with all modern appliances for the rapid and economical handling of the work.

After being cast, fettled and annealed, the castings are despatched by the firm's steam lorries to the machine and grinding shops of the tramway and railway department, in Shepcote-lane, described and illustrated on page 272, *ante*. The illustration, Fig. 19 on page 306, shows the charging of crucible furnaces.

The buildings of the various shops in this, the older part of the works, are of an old date, and their construction does not call for any special notice. The cranes and machines are electrically driven throughout, the power being obtained from the Sheffield Corporation and converted from alternating to continuous current through Vickers' rotary converters, situated in the transformer house near to the boilers. The press shop is supplied with steam by a battery of three 30-ft. by 8-ft. Lancashire boilers, conveniently situated for the supply of fuel *via* a siding alongside the boiler pit from the Great Central Railway.

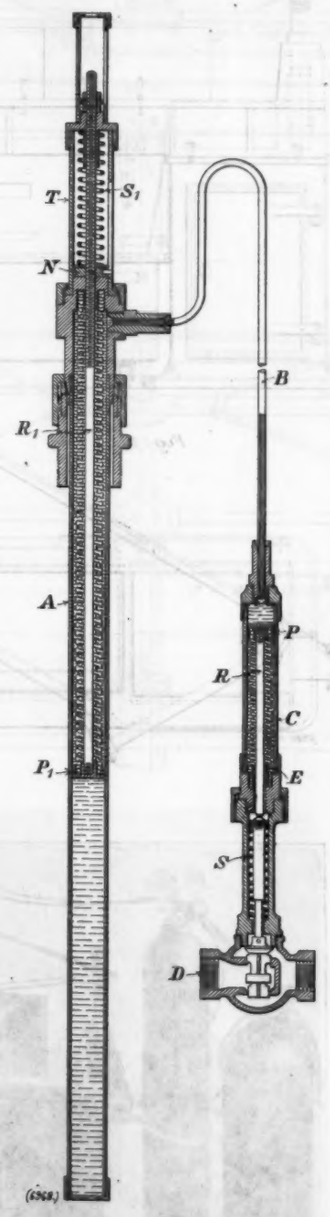
(To be continued.)

THE "SAMSON" AUTOMATIC TEMPERATURE REGULATOR.

An interesting form of temperature regulator, known as the "Samson," is illustrated in the annexed figure. It can be applied for operating steam, gas, oil or water valves, or for controlling electric switches. It is applicable to the regulation of room temperatures and has many more strictly technical uses, as, for instance, for the temperature control of feed-water heaters, sterilisers, ovens of various kinds, paper and timber drying plants, &c. It may also be applied to cooling plants of every description. The apparatus is entirely self-contained and no outside source of energy is required to operate it, so that in the case of an installation comprising several regulators they cannot all be put out of action at once by the failure of a central source of energy. In the operation of the regulator the valve under control is gradually closed as the temperature rises, so that after-heating effects, when the valve is completely closed, are less marked than with devices which suddenly shut a fully-opened valve when the predetermined maximum temperature has been passed.

The regulation operates by the rapid expansion and contraction of a liquid highly sensitive to temperature variations, the pressure generated by the expansion of the liquid being applied to a special form of frictionless piston. The details of the device will be followed from the figure. In this, A is the thermostat connected by the tube B to the controller C which operates the valve D, which opens, or closes, the steam, hot water or other connection. The parts A, B and C are completely filled with the operating liquid and are hermetically sealed. Inside the controller there is a long piston P which is constructed of seamless spirally-corrugated tubing of great elasticity and resiliency, and made from a copper alloy. The piston is hermetically attached to the casing at E, and at its top end is closed by a cap in which a rod R is fixed. The rod passes through the interior of the piston. It should be understood that the cap is a free fit in the controller chamber C and that the operating liquid can flow past it freely. The rod R bears on the top of the valve stem as shown. With a rise in temperature the internal pressure rises and some liquid passes over from the thermostat to the controller. The result is that the piston is compressed and the rod R moving downwards closes the valve. This effect obviously takes place gradually as already described. With a fall in temperature the rod R lifts and the valve is opened again under the action of the spring S.

The thermostat is also fitted with a long piston P_1 of the same type as P. This serves as a regulator, and also acts as a safety device. Towards the upper part of the internal rod R_1 of this regulating piston there is a circular nut N which can be rotated by means of the tube T, but is held in position by the spring S_1. It will be evident from the figure that by rotating this nut the regulating piston may be either extended or contracted so that more liquid is forced into the controller or withdrawn from it. This results in the valve D being moved nearer to, or farther away from, its seat, and enables the regulator to be set so that final closing of the valve takes place at any selected temperature. The spiral corrugations of the tube piston cause the whole tube to take part



uniformly in any expansion, or contraction, which has the result of dividing the stress evenly and increasing the resiliency. If the valve D is completely closed and the temperature still continues to rise the pressure set up in the thermostat compresses the regulating piston and lifts the rod R_1 and with it the nut N against the action of the spring S_1, and so relieves the pressure. The thermostat tube is normally made of brass, but when it is to be used for liquids which have a corrosive action on brass other material can be used, or it can be lead-coated. It should be noted that the regulators contain no tight-fitting parts and so are free from metallic friction. The agents for the regulator are Messrs. Buck and Hickman, Limited, of 2, 4 and 6, Whitechapel-road, London, E. 1.

NOTES ON NEW BOOKS.

Everyone who has had experience in the control of steam plant must recognise the desirability of the men in charge of boilers being thoroughly conversant with the special features of the type of steam generators with thich they have to deal, and for this reason we welcome the publication of a small handbook entitled "*Boiler Inspection and Maintenance*," which has just come into our hands. The book, which is by Mr. Reg. Clayton, and published by Sir Isaac Pitman and Sons, Limited (Price 2*s.* 6*d.* net), is intended to promote efficient boiler inspection by giving full information as to the probable sources of trouble in boilers of various standard types and indicating how these troubles should be dealt with. The examination and maintenance of boiler accessories such as superheaters, economisers and fittings generally are also treated, and the advice given is of a thoroughly practical character in every respect. We can strongly recommend the book to all interested in the efficient and economical maintenance of boilers.

In recording the activities of the British mercantile marine during the Great War, the difficulty lies mainly in selecting items of outstanding importance from others of almost equal interest and merit. This trouble, we feel confident, must have been experienced by Mr. H. W. Leslie, in preparing an account of the operations of the ships of the Royal Mail Steam Packet Company from 1914 to 1919, which has been published by Mr. William Heinemann, under the title "*The Royal Mail War Book*," at a price of 10*s.* 6*d.* net. Although much matter has, doubtless, been omitted by the author, the events chronicled form a narrative of absorbing interest, which give the reader a faint, but accurate, impression of the difficulties and dangers encountered by the men of the mercantile service in carrying on the nation's maritime transport work. In all branches of this work, which included the transport of passengers and goods, troops and war supplies, the provision of armed-merchant cruisers, the conveyance of sick and wounded, and the countering of German espionage and propaganda work, the ships and men of the Royal Mail Steam Packet Company played a part which, if equalled, can hardly have been excelled. Probably it is typical of those of many other shipping companies, to all of which the nation owes more than is generally realised for the successful conclusion of the struggle, but the fact that this particular record is presented in a concise, convenient and readable form, gives it a special advantage over those which are less easily accessible. The events recorded, some even humorous, but many tragic, are illustrated by numerous reproductions from photographs and drawings, and to select any of them for special reference is a task of almost equal difficulty to that of the original compilation. The one that seems to us to be the least easily forgotten is the torpedoing of the hospital ship Asturias, without warning, in the Channel on the night of March 20–21, 1917. Good fortune and excellent seamanship on this occasion, rendered the loss of life far less than was to have been expected, but this action and many others of a similar character set a stigma on the German nation that will require very many years completely to efface.

OXY-ACETYLENE CUTTING MACHINES.

(*Continued from page* 275.)

In our previous article we described a portable machine for cutting metal up to 20 in. or 22 in. thick, in straight lines, or to circular profiles. We now propose to describe two larger machines for dealing with work of any profile, using a drawing or template which a driven tracer is made to follow by hand. It will be remembered that the Camograph constructed by The Davis-Bournonville Company, of Jersey City, N.J., U.S.A., and described in our Vol. cix, page 606, is a portable metal cutting machine, mainly intended for cutting openings of the manhole class in plates, &c. That machine is automatic in that the torch follows and is held up automatically to a copying plate. The machines we are about to describe have a much wider range than the Camograph, but the guiding of the moving torch is controlled by hand.

The machines we now intend to deal with are the No. 1A and No. 2A Oxygraph, also constructed by The Davis-Bournonville Company, of Jersey City. The No. 1A Oxygraph is illustrated in Figs. 8 to 11, page 308. The machine consists of a pantograph gear carried by a standard fixed to a large bed. The bed is supported at a height of 2 ft. 6 in. from the floor, on two cabinet legs. The overall surface of the bed is 5 ft. 9 in. long, by slightly less than 1 ft. 10 in. wide. The pantograph column is at the left-hand end. At the right is a sliding table carried by two lengths of rolled 2½-in. by 2½-in. steel joist. This table is of steel plate, and is 3 ft. square. On it is laid out the drawing or template of the job to be done. The work is supported over the

THE OXYGRAPH OXY-ACETYLENE CUTTING MACHINE.

CONSTRUCTED BY THE DAVIS-BOURNONVILLE COMPANY, ENGINEERS, JERSEY CITY, N.J., U.S.A.

Fig. 8.

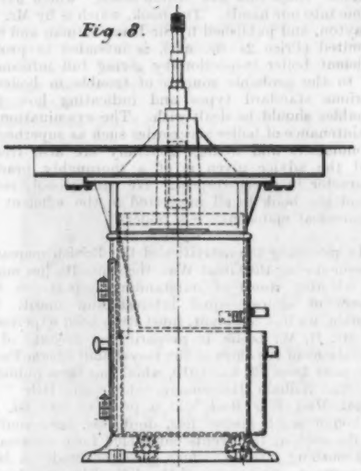
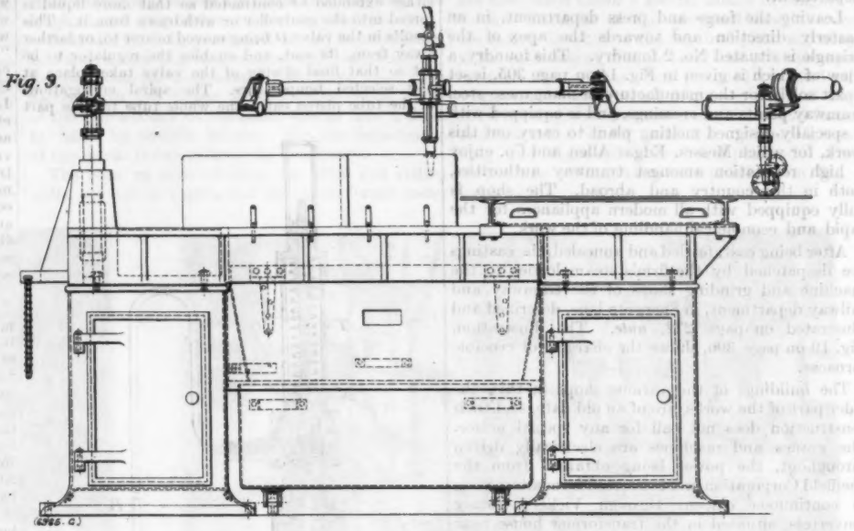


Fig. 9.



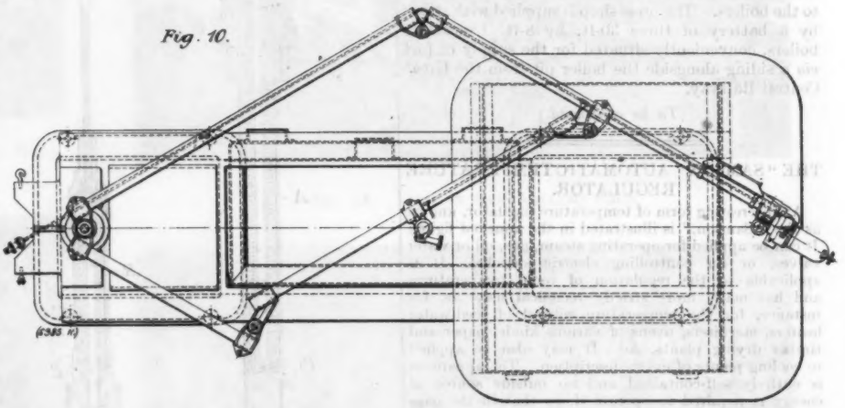
middle of the bed by two lengths of deep section of steel joist. The bed is of skeleton form with two wide flat faces to support the sliding table and work joists. These faces are carried by deep longitudinals provided with stiffening ribs at intervals. At either end the bed is formed like a rectangular trough, but in the centre there is no bottom extending between the longitudinals which are thus spaced apart with an opening about 12¼ in. wide between them. This will be clear from Fig. 11. This central opening is fitted inside with a thin sheet metal chute, below which is arranged a deep trough on wheels, which receives the *debris* from the cut.

The pantograph column is 2 in. in diameter and is fixed in a tall boss which forms part of the bed casting and is well stiffened by ribs. The pantograph is of tubular construction, the diameter of the members being 1¼ in. The pivots are all fitted with ball bearings, including the supporting column. A reduction of one-half is made with this machine so that the drawing to be used on the table has to be twice full size. The torch and tracer are illustrated and are the same as for the No. 2A Oxygraph machine, to which we will therefore pass at once. This machine will, we understand, be exhibited in use at the forthcoming Shipping, Engineering and Machinery Exhibition at Olympia.

The No. 2A Oxygraph is illustrated in Figs. 12 to 19, page 309; this is a larger size machine, and reproduces cuts to the same scale as the model or drawing. The frame in this case consists of two 8-in. channels bolted to three leg castings. The length is 9 ft. and width across the top is 2 ft. 5 in., the height from floor to the top of the frame or bed is 2 ft. 4 in. At the back of the machine two bracket arms are bolted to the end legs and a stay extends between them as shown in Fig. 14. These arms carry the pillars supporting the pantograph frames. The pillars are adjustable for height, being moved up and down by rack, and the hand wheel shown in Fig. 14. There are two frames connected by a crossbar at the front, and by a second bar coupling the right-hand corner joint of the two frames. Each framework is suspended from a pillar by two stays running from the pillar head to the parallel frames near the right and left-hand joints. The machine is fitted throughout with ball bearings. The main swivels on the pillars are fitted with the bearings shown in Fig. 18. Fig. 16 shows the bearings for the caps to which the supporting stays are attached. The two left-hand joints are shown in Fig. 17. In these joints the back limb is fitted with jaws, between which the end of the front limb is held by coned points adjusted in ball bearings. The two front joints are illustrated in Fig. 19. In this figure the central member is one of the front limbs of the pantograph held between the two jaws of the other. Outside the latter jaws are the bearings for the jaws of the bracket carrying the cross-bar coupling the two frames. Fig. 15 shows the right hand joints of the frames, and the casting carrying the second cross-bar already referred to.

The torch or torches, as the case may be, two being shown in adjustable holders on the front cross-bar in our illustrations, are similar to those of the No. 1 machine. The motor-driven tracer is also similar. In the photograph reproduced in Fig. 14 the tracer is shown

Fig. 10.



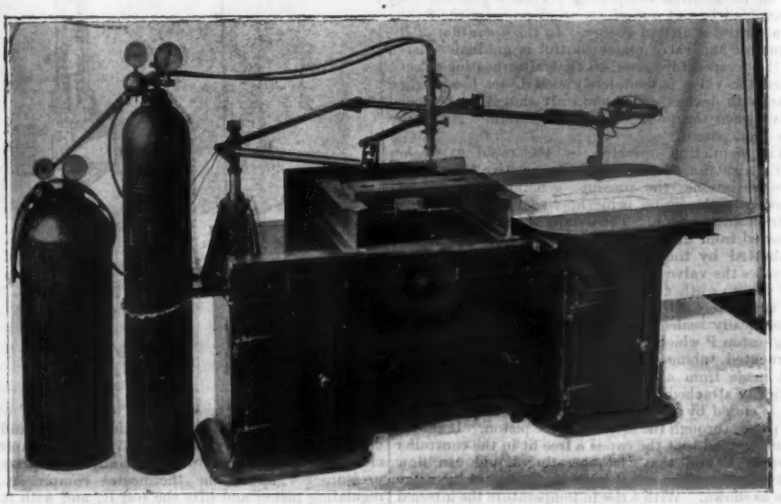


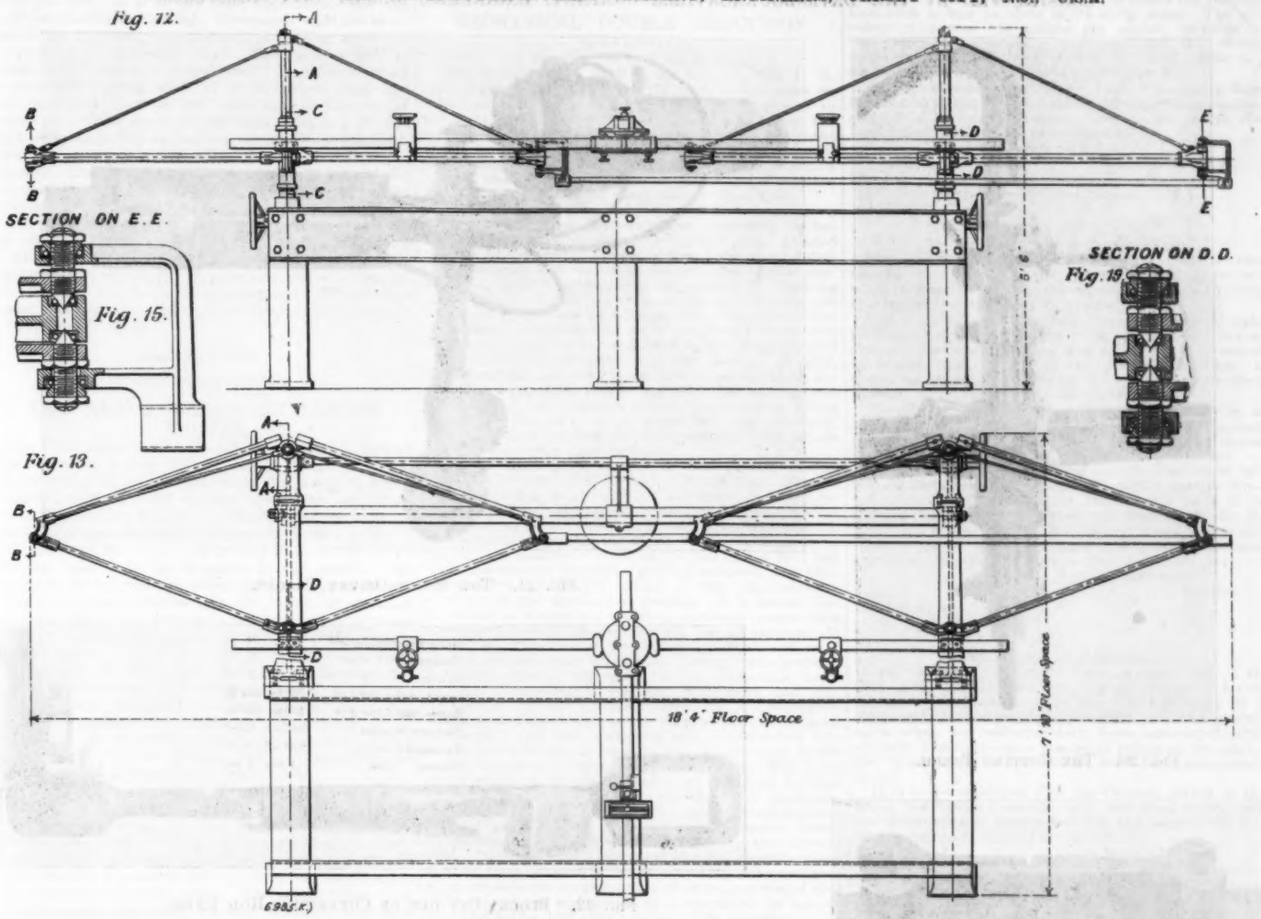
Fig. 11. General View of Oxygraph No. 1a.

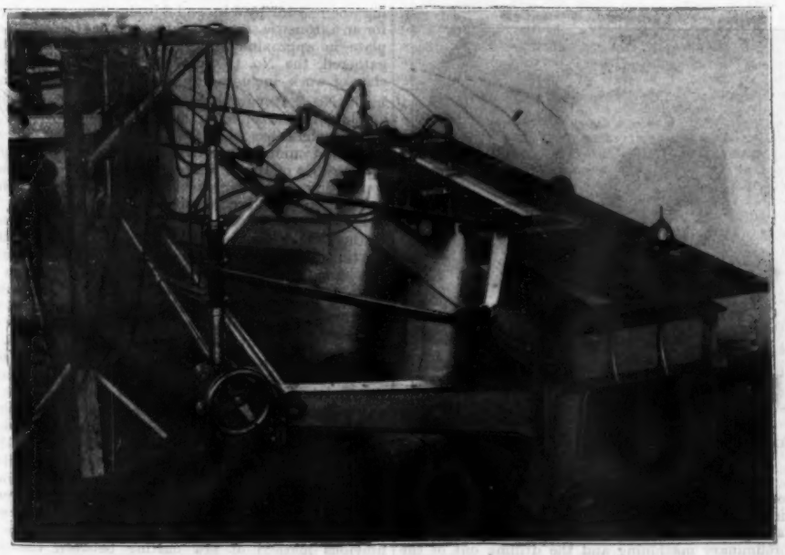
fixed to the cross-bar for use with a templet clamped to the slab being cut. The tracer may, however, be attached to a sliding arm to be seen in Fig. 13 set at right angles to the cross-bar, and capable of being extended beyond the machine frame top to an adjustable table, 36 in. square, placed in front of the machine. The work is supported on joints stretching across the frame. In both machines the connections for the motor are joined up with the cutting oxygen cocks so that when the latter are opened the tracer wheel commences to travel over the templet or drawing.

The torch and motor-driven tracer suitable for either of these machines are further illustrated in Figs. 20 and 21, page 310. The torch, Fig. 20, is carried in a sleeve in which it can be raised or lowered to suit the

THE OXYGRAPH OXY-ACETYLENE CUTTING MACHINE.

CONSTRUCTED BY THE DAVIS-BOURNONVILLE COMPANY, ENGINEERS, JERSEY CITY, N.J., U.S.A.





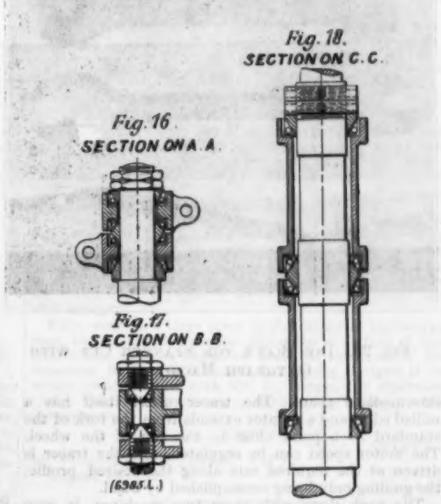


FIG. 14. GENERAL VIEW OF OXYGRAPH NO. 2A.

height of the work being operated upon. The milled head, and rack for this motion are clearly seen in Fig. 20. At the upper end of the torch are two cocks and a needle valve. These are arranged in a similar way to those previously described in connection with the Radiograph. The upper cock is for the pre-heating flame of acetylene and a small supply of oxygen regulated by the needle valve. The lower cock is for the supply of oxygen for the cutting flame, and when this is turned on, the movement actuates an electric switch seen on the left side of the torch and cuts in the driving motor, which is shown in Fig. 21. The electric leads in the No. 1 machine will be seen from Fig. 10, to be brought up to the pillar at the left-hand of the machine, carried along inside the back members of the pantograph, through the back hinge, and to the motor, being branched to the torch up one of the front tubes, on the way. As already stated, the No. 2 machine is wired on similar lines, but the leads are not run through the tubular limbs.

The motor-driven tracer is illustrated in Fig. 21. The motor is carried by a bracket on the end of the pantograph arm and drives the tracer wheel by means of a small worm and a worm wheel on a vertical spindle passing down through the swivelling standard. At its lower end the spindle has another small worm which drives a large toothed wheel on the tracer wheel through

THE OXYGRAPH OXY-ACETYLENE CUTTING MACHINE.

CONSTRUCTED BY THE DAVIS-BOURNONVILLE COMPANY, ENGINEERS, JERSEY CITY, N.J., U.S.A.

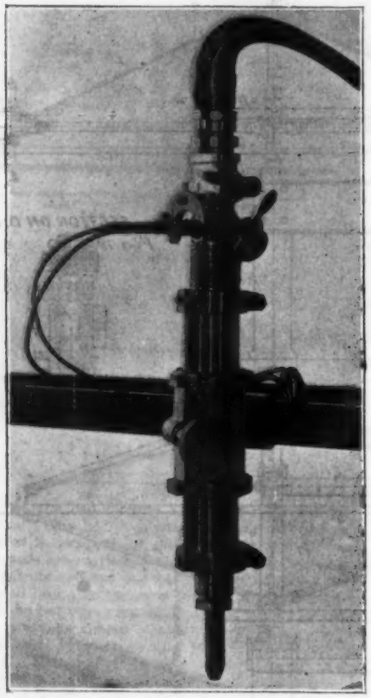


Fig. 20. The Cutting Torch.

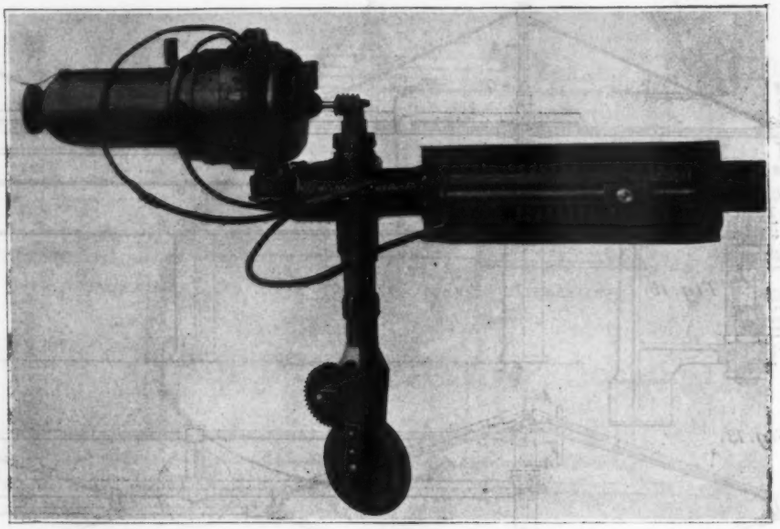


Fig. 21. The Motor-Driven Tracer.

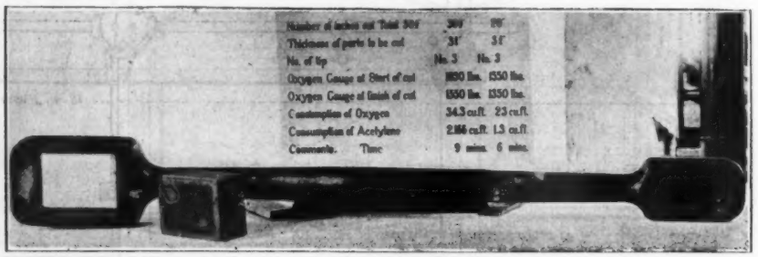

Number of inches cut Total 30½ 30½ 0½
Thickness of parts to be cut 3½ 3½
No. of tip No. 3 No. 3
Oxygen Gauge at Start of cut 1850 lbs. 1550 lbs.
Oxygen Gauge at finish of cut 1550 lbs. 1350 lbs.
Consumption of Oxygen 34.3 cu.ft. 23 cu.ft.
Consumption of Acetylene 2.166 cu.ft. 1.3 cu.ft.
Comments. Time 9 mins. 6 mins.

Fig. 22. Blocks Cut out of Connecting-Rod Ends.

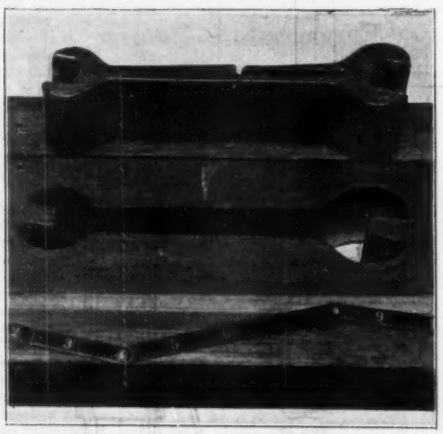


Fig. 23. Die Block for Spanner Cut with Oxygraph Machine.

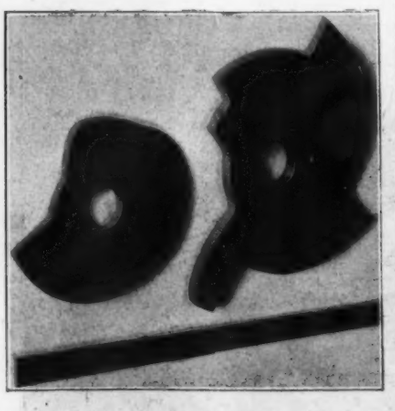


Fig. 24. Cams Cut with Oxygraph Machine.

intermediate gears. The tracer wheel itself has a milled edge, and a pointer extends from the fork of the standard to a point close to the rim of the wheel. The motor speed can be regulated, and the tracer is driven at the required rate along the desired profile, the guiding only being accomplished by hand.

The work done with these two machines is very diverse in character. For instance, connecting rods about 16 in. long, with solid ends, have been cut straight out of billets 1¼ in. thick, and the square holes cut for the brasses in 8 minutes actual cutting time. This job is shown on the table in Fig. 11, page 308. The total length of cut, amounting to 60 in., is taken at a rate of 8 in. per minute. The time for forging a similar piece would, of course, be far more.

Another connecting-rod job is shown in Fig. 22. Here the metal was 3½ in. thick and the times were 9 minutes for the big end and 6 minutes for the small end, the lengths of cut being 30½ in. in one case and 20 in. in the other. The total consumption of oxygen was 57·3 cub. ft. and of acetylene 3·466 cub. ft.

A very neat piece of irregular work is shown in Fig. 23, which illustrates a die for a spanner cut on one of these machines, with the piece cut placed behind. For die work these machines present many advantages. Die work as a rule involves a good deal of preliminary machining and the drilling out of the block and subsequent finishing by machine and hand. Usually a die made in this way warps when hardened and requires grinding up again or packing in the press. In cutting by the oxy-acetylene process the block is preheated and cut before planing, and while hot is placed in an annealing box, in which it is slowly allowed to cool out. This process is found to relieve the internal stresses in a much more satisfactory manner, so that after finishing and hardening failures from cracking are practically eliminated. Another example of irregular cutting is illustrated in Fig. 24, the two cams measuring about 3 in. by 5 in. and 3 in. by 9 in., respectively, for an automatic screw-machine, and cut from ½-in. steel plate in approximately 3 minutes each. As will be gathered, the No. 1 Oxygraph is used for the smaller class of work, including die work of all description.

The No. 2 Oxygraph is used for larger work, either employing one torch, or more, according to the job. This machine has been used for cutting out the side frames of mine locomotives, tadpole ends of rudder forgings out of 10½-in. ingots, crank webs, mast bands, connecting rods for locomotives, quadrant links, eccentric rods and many other engine parts, &c. The cut may be started at an edge, or at a perforation made by the torch, if the piece is not convenient to drill with a starting hole. A typical job on which the No. 2 machine has been used is the cutting of mast bands from the solid, instead of finishing them by forging. In one case of bands for an 8½-in. mast with two single and two double lugs the net cost to forge and finish forge was 194·79 dols., compared with a cost of 136 dols. for cutting out of a rough forging; the blocks were 6 in. thick and the rate of work 5 in. to 6 in. per minute. Another instance may be given of a davit collar cut out from a solid rectangular block forging 6 in. thick, in 15 minutes, at a total labour cost of 1·05 dols., using 207 cub. ft. of oxygen, making the cost for labour and gas, of shaping the outside contour and cutting the davit post socket 3·19 dols. Three-throw crank-shafts have been cut from forgings 18 in. in diameter and 6 ft. long, cutting out the complete blocks between the webs in about 8 minutes, compared with the previous method of saw cutting between the webs and then breaking out the central piece.

With the extension bar fitted to the cross bar of the No. 2 machine, and the torch carried on this extension piece very large work can be satisfactorily accomplished. For instance, torpedo-boat bulkheads have been perforated by lightening holes ranging from 6 in. to 14 in. by 17 in., by means of this outfit, the plates measuring 9 ft. by 14 ft.

Interesting instances of work done with these machines could be cited in numbers, but it is unnecessary to multiply them. The question of the effect

of the cutting flame on the quality of the metal is, however, of importance. In this connection tests on chrome-nickel steel may be quoted, in which steel containing 1·25 per cent. to 1·75 per cent. Ni, and 0·45 per cent. to 0·65 per cent. chromium, was cut and tested after machining. Compared with hot sawn pieces the oxy-acetylene method of cutting appeared to produce no untoward effect. The same applied to a test of 3·5 per cent. nickel steel. In ordinary work a four-throw crank shaft of 0·35 carbon steel was cut, and test coupons cut from one of the blocks removed. These were planed down with a ¼ in. cut and were subjected to bending on an Olsen machine. The pieces bent double without sign of hardening cracks. The thickness of steel cut was 7½ in. and the oxygen pressure used 80 lb., the area cut per cubic foot of oxygen being 3 sq. in.

The last instance we give is of die-block cutting in steel containing 0·54 carbon, 0·80 chromium, 1·62 nickel. The thickness of metal was 12¾ in., and length of cut 14½ in. Oxygen was used at a pressure of 140 lb., 105 cub. ft. being consumed. The cutting speed was 3 in. per minute, and the area per cubic foot of oxygen 1·7 sq. in.

(To be continued.)

THE NEALE SUBMARINE LIFTING MAGNET.

On Wednesday last, at the Albert Dock, we witnessed the trials of a new lifting magnet designed for use under water in connection with the work of wreck removal, and also for salvage operations and other work of a similar character. The body of the magnet, which is of cast-steel and is octagonal in plan, measures 3 ft. between the sides, and is only 2½ in. thick with a circular hole 1 ft. in diameter in the centre. The windings are enclosed in water-tight casings and fitted into four circular recesses in the lower, or working, face, and they are so arranged that the intervening ridges of metal form five annular pole pieces of opposite sign. Narrow spaces are left between the winding casings and the body, and holes drilled through the latter communicate with these spaces, so that water can circulate round the windings to cool them and allow a comparatively high current density to be employed. A shackle connected to steel plates bolted on to the top of the body is provided to enable the magnet to be attached to a crane hook.

The magnet, we understand, is intended mainly for lifting masses of ships plating detached from a wreck by explosives or other means, and it will be obvious that, by dividing up the working face into narrow rings as above described, a strong field, and consequently a powerful lifting effect, can be obtained in a comparatively thin plate. The actual lifting force of the magnet employed, we were informed, was from 10 tons to 15 tons, with a current of 16 amperes at 220 volts pressure, but the lifting power naturally varies according to the degree of contact obtainable. The magnet itself, it may be mentioned, weighs only 7 cwt.

To demonstrate its capacity, a number of heavy bodies, including a piece of steel plate 4 in. thick, a complete railway crossing, a piece of boiler plate about 6 ft. square, and three steel joists clamped together weighing 2½ tons, were dropped into the dock in about 30 ft. of water. All were afterwards successfully recovered from the mud at the bottom of the dock by searching for them with the magnet. Some difficulty was certainly experienced with the railway crossing, which, when invisible, would naturally be a troublesome object to attach a magnet to. The services of a diver had, in fact, to be employed to secure the necessary contact. Another slight mishap, which might really go unrecorded since it could so easily have been avoided, was the detachment of the magnet from the crane hook on the bed of the dock; neither of these circumstances, however, can be regarded as a reflection on the efficiency of the magnet. This is certainly materially higher than that of some magnets already on the market, as the following particulars of a comparative test will show: A certain magnet purchased from stock was used to lift two rolled-steel joists measuring 12 in. by 12 in. by ¾ in. thick, each 30 ft. long, and weighing approximately 5,500 lb. together. This magnet weighed 55 cwt., and the power absorbed for the lift was 8 kw., whereas the Neale magnet, which, as previously mentioned, weighs only 7 cwt., required only 1 kw. for the same lift.

Similar magnets are, we understand, being designed by the Neale Magnet Construction Company, Limited, 7, Suffolk-street, Pall Mall East, S.W.1, for various industrial applications, one of which is the lifting of red-hot plates and sections in rolling mills. For this work the windings are cooled by a blast of compressed air. Magnets suitably designed on the principle outlined above can, of course, be employed for the more usual applications of lifting cold plates and sections, pig-iron, scrap, magnetic materials in boxes, &c., but the one actually used in the demonstration is unsuitable for continuous working in air, since water is relied upon for cooling the windings.

MECHANICAL DOUBLE REDUCTION GEARING.

To the Editor of Engineering.

Sir,—I have read with much interest Mr. J. H. Macalpine's Appendix (page 179 *ante*) to his paper on "Mechanical Double Reduction Gearing," written in the light of Messrs. Walker and Cook's paper at the meeting of the Institution of Naval Architects, and the discussion thereon. I hope Mr. Macalpine has contributed these views to the Proceedings of the Institution so that the authors of the paper may be in a position to reply formally to the statements he has made.

I regret that, so far as Mr. Macalpine's comments on my remarks at the discussion are concerned, he has been somewhat misled by an abbreviated report. I stated that, as an Admiralty Inspector, it was one of my duties to investigate the causes of breakdowns of Parsons' turbines, not "breakdowns of gearing." Knowing Messrs. Parsons' methods to be sound and their designs to be correct, it was by analogy that I concluded that any gearing troubles that have manifested themselves were also largely to be attributed to bad workmanship or carelessness—certainly not to design. Further, Mr. Macalpine seems to think that I cast doubt on the authors' suggestion that "higher tooth loading was practicable." As a matter of fact, I was merely asking for information as to ships which had high constants, and which had operated for comparatively long periods at these relatively high loadings.

Mr. Macalpine gives us a list of some 17 ships having high coefficients which have carried out long distances without giving any trouble. We have, however, no guarantee that these vessels have been actually worked at their designed full power. The ships are, it is believed, of the small cargo carrying type. What we do know is, that a large number of ships built in the States have had their mechanical reduction gearing removed, and electrical drive substituted, owing to the unsatisfactory working of the mechanical gearing. It is hardly fair to make a statement showing successes unless this statement is accompanied by the list of failures. It would be interesting if Mr. Macalpine would tell us if the failures were also fitted with floating frame gears.

In my remarks regarding the ss. Cameronia, built by my firm—Messrs. William Beardmore and Co., Limited, of Dalmuir—I stated that we had not, during the trials, been allowed to steam the vessel at her full-designed power, and that the coefficient had only reached 170. Since that time the Cameronia has steamed over 20,000 miles, being now on her fourth trip home from New York, and worked up to the full designed figure on her last voyage. The reports of the operation, and condition, on examination of the gear, are extremely satisfactory, and the tooth loading on the second reduction pinion has now exceeded 1,100 lb. per inch run, and the constant 220. An independent engineer, who has recently made the trip from Glasgow in this ship, and has had experience of an exceedingly large number of ships, has stated that "for smoothness and quietness of operation, he has yet to come across this ship's equal. The vibration is nil at full power, and the noise not in excess of that of a first-class single-reduction gearing." I mention these facts to bear out the contention in my remarks on Messrs. Walker and Cook's paper, that first-class material and workmanship will give the most excellent results, and that it is simply to defects in these particulars rather than to design, that the early troubles with mechanical double-reduction gearing must be principally attributed. The Cameronia's gearing has been opened out and examined each time the vessel has arrived in the Clyde, and is in beautiful condition. Messrs. Lloyd's representatives were invited to inspect the gearing on the last occasion, and made complimentary remarks.

I am, Sir,
Yours faithfully,
W. Onyon.

Naval Construction Works,
Dalmuir, Dumbartonshire.
August 23, 1921.

THE JUNIOR INSTITUTION OF ENGINEERS.

To the Editor of Engineering.

Sir,—Your leading article of the 12th inst. appears most opportunely, for in the opinion of many of the well-wishers of the Junior Institution of Engineers, the Institution, on its present course, is drifting to inevitable disaster. The writer, whoever he may be, is doing a real service to the Juniors by his candid comments and warnings. If his identity were revealed, I should not be at all surprised to find that he is one of those who had the joy of living as a member in the exhilarating atmosphere of the Institution years ago, when "founded for the Junior members of the profession" was established as its guiding principle.

Until recent years the full meaning of this phrase has been exemplified in all the Juniors' doings. Surely, no member has the idea of eliminating "The Junior" from the title of the Institution; and yet when one sees in recently-issued notices, &c., these words so much reduced in proportion to "Institution of Engineers"—well—*verbum sat sapienti*. But perish the thought—moreover, there is an Institution of Engineers in India.

With Mr. Tennant's letter in your present issue I am in full agreement, excepting as regards the inference which I draw from its concluding sentence as to increasing the subscriptions. Certainly, costs have gone up, and revenue must be obtained to meet them, but I suggest that it should be by some other means than by the apparently simple one of piling up the subscription.

I suppose many of those starting on their career to-day are not better off than were they who found the Institution such a help to them in its early years. The old subscription was one guinea per annum, payable in half-yearly instalments. A society for the young beginner should be placed within his reach. How can he join if the subscription is prohibitive?

As a member since December, 1884, I earnestly hope that acting on the advice of their old friend Engineering, steps will be taken without delay to restore to the Institution its original characteristics.

I am, yours faithfully,
Walter T. Dunn.

The Institution of Gas Engineers,
30, Grosvenor-gardens, Westminster, S.W.1.
August 22, 1921.

To the Editor of Engineering.

Sir,—As a member for over 20 years, I should like to add my thanks for, and express my full agreement with, your article on the revolutionary proposals affecting the Junior Institution of Engineers.

The meeting at which these proposals were brought forward was called for July 8 last, at a week's notice, and a subsequent meeting was called for this month to confirm the decision of the previous meeting. It would be interesting to know the number of members present, and voting, at these meetings.

Usually no meetings are called in these months, as there is no possibility of any adequate attendance, and it seems unfortunate that so important a matter should have been rushed through in the holiday months.

If these proposals are carried out the Institution will lose its distinctive character and another Institution—not ashamed of being called Junior—will have to be formed to carry on the work and keep alive the old spirit which the present Institution would relinquish. There is no use for an Institution such as would result from the proposed re-organisation.

I am, Yours truly,
"Patent."

London,
August 23, 1921.

To the Editor of Engineering.

Sir,—Referring to the editorial in your issue of the 12th inst. dealing with the above, the very kindly reference you have made to the Junior Institution of Engineers has been greatly appreciated, and the comments upon what has unfortunately been considered—erroneously, I submit—as a change of policy on the part of the Council of the Institution have been particularly noted.

It is to be regretted that the Council, owing to this being the holiday month, will not meet again until the third week in September, but the matter will then be put before it for full discussion.

Yours faithfully,
W. A. Tookey,
Hon. Secretary and Treasurer,
Junior Institution of Engineers.

39, Victoria-street, Westminster, S.W.1.
August 24, 1921.

JUBILEE OF THE JAPANESE GOVERNMENT RAILWAYS.

To the Editor of Engineering.

Sir,—May I crave the hospitality of your columns in an endeavour to collect whatever information I can for the purpose of the above-named Jubilee?

The chairman of the Committee of the Government Railways Jubilee, writing recently to me from Tokio, makes the following request:—

"The Japanese Government Railways is going to celebrate the fiftieth anniversary of its inception in October this year. In connection with this, we shall be much obliged if you will kindly let us know the name, address and brief record of career of any British subjects who came over to Japan to serve in our railways and are still alive."

Fifty years is a large span in the career of the active man, but should this request arrest the attention of any reader who went to Japan to assist at the birth of the Japanese Railways, I should be greatly obliged if he would communicate with Mr. U. Beppu, the chairman of the Jubilee Committee, or with me as acting for the Committee.

Yours faithfully,
Geo. Cawley.

82, Victoria-street, London, S.W.1.
August 23, 1921.

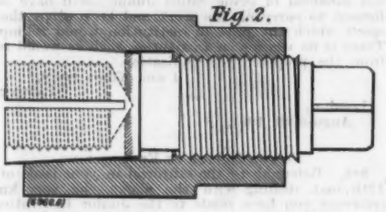
Industrial Administration.—Arrangements have been made by the Manchester Municipal College of Technology for a course of lectures on Industrial Administration. The scheme of studies will deal with Industrial History, Labour Aspirations and Economics; the Technique of Management and personal questions. The scheme is, it will be seen, a comprehensive one; but it may be difficult to secure really competent and trustworthy lecturers. Probably the majority of University lecturers on economics and similar subjects, have the characteristics of the lawyer and politician, rather than those of the engineer, and are accordingly more anxious to make out a case for their own particular creeds, than to establish by observaton and (where possible) by experiment how policies really do work out in practice.

THE DRYSDALE STUD EXTRACTOR.

In repair and maintenance work it is often necessary to extract studs, while in new work it is of course constantly necessary to drive them. The methods and appliances used in shops for these operations vary from the crude but useful kink of two locked nuts, to elaborate devices which are often more costly than they are worth. A simple extractor which was originally introduced in a Scotch shipyard is illustrated in Figs. 1 and 2 herewith. It is known as the Drysdale stud extractor and is manufactured in several sizes by Messrs. Alfred Herbert, Limited, Coventry. The illustrations are practically self-explanatory. The

Fig. 1.

Fig. 2.



extractor consists of a body, one end of which is split after the manner of a collet. The outside of this body at the split end, is tapered, while the inside is bored and tapped to the stud size. At the other end the body is screwed, and finished with a square end to fit a tap wrench or spanner. Over this body screws a sleeve bored at the bottom end to a taper corresponding to that on the body, and cut on the outside to form a hexagon nut.

In use for driving a stud the body is screwed over the stud and the sleeve tightened down, the stud being thus grippod by the split ends of the body. If the square end is held for a moment and the hexagon nut turned back the tool is released. In extracting when the tool has been screwed on to the stud the square end is held while the sleeve is tightened up and, when tight, the stud can be withdrawn by screwing back by means of a wrench on the square end.

Rock Salt in the United States.—The United States, favoured as to petroleum, also seem to be favoured as to the deposits of rock salt. According to the United States Geological Survey a large bed of rock salt extends from Northern Kansas in a south-westerly direction across the States of Oklahoma, part of Texas and New Mexico into Western Texas, in a belt about 650 miles long and from 50 miles to 150 miles wide. The rock salt is found at depths ranging from 300 ft. down to 700 ft. Assuming an average thickness of a layer to be 200 ft., the deposit would contain 30,000 billion tons of salt, and would thus probably be the largest rock salt deposit of the world.

Explosives in 1920.—The annual Report of H.M. Inspector of Explosives for 1920, records a further diminution in the number of factories on the books, 133 against 147 in 1919, which is mainly due to the amalgamation of the chief manufacturers into the firm of Nobel's Industries, Limited. Compared with 1885, the increase in the number of employees, 7,484 then, against 13,103 now, is much more striking than the increase in the number of factories, 108 to 133. The imports of explosives amounted to 433,650 lb., and 389,989 lb. of aluminium torches made up the main bulk of these imports. Thirteen new explosives were submitted for examination, and two of these were rejected. The quantities of explosives used in mines have not fluctuated much during the war years; they amounted to 30,215,155 lb. in 1915, rose to 31,737,651 lb. in 1917, and decreased to 27,139,391 lb. in 1919. The number of accidents due to explosives are of the order of the averages of the ten years before the war; in the years 1905 to 1914, there were, on an average, 434 accidents per year, killing 56, and injuring 434 people. For the year 1920, the numbers were 438 accidents, these resulting in 50 deaths and 455 cases of injury; 76 of these accidents were connected with the manufacture of the explosives, killing two people and injuring forty-four.

PNEUMATIC GRAIN-DISCHARGING AND SACK-HANDLING PLANT AT BORDEAUX.

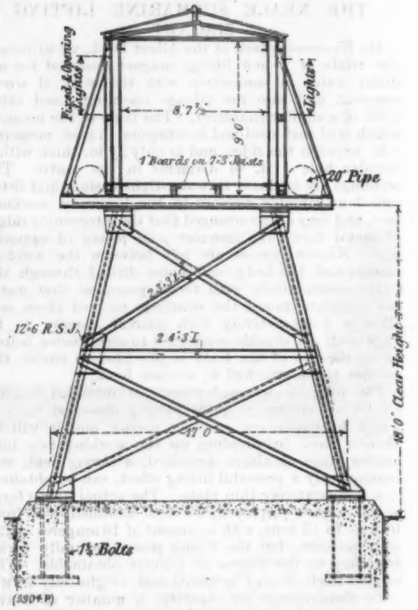
During the war the port of Bassens, on the Garonne, close to Bordeaux, was developed partly by the French Government, but to a greater extent as a base for the American Army. The development thus brought about has been turned over successfully with several alterations, to the requirements of peaceful commerce. A company known as the Union Commerciale de Bordeaux-Bassens was formed, we believe, in 1918, to develop, among other things, the grain handling facilities of the port, and we are enabled in this issue to illustrate the thoroughly up-to-date plant which has just been completed for this purpose. A jetty 150 yards long is made use of for berthing the ships. On this jetty are two travelling pneumatic grain-discharging installations, delivering on to elevated belt conveyors running the length of the wharf. These conveyors in turn deliver to others running at right angles to them, back to silos of 7,500 tons capacity, whence the grain may be sacked off and stored in warehouses having an aggregate floor area of 12,000 sq. yards. This area consists of five sheds of reinforced concrete, all served by belt conveyors and double railway tracks. General section and lay-out of the plant are given in Figs. 1 and 2, Plate XV, with this week's issue of Engineering, and elevations to a small scale in Figs. 5 and 6 show the arrangement of the gantries carrying the belt conveyors. Figs. 3 and 4 give sections of the silo building, &c. A general view of the installation is given in Fig. 17, page 316, in which the various features above referred to will be easily recognised.

The pneumatic plant is unusual in that the vacuum pumps or exhausters are in the building annexed to the silos, and at a considerable distance from the moving towers on the wharf. To connect the two, 24-in. steel mains are run along the conveyor gantry, connecting with 20-in. mains along the wharf conveyor gantry. Flexible connections from these to the towers may be made at 20 different points. The conveyors have a combined capacity of 300 tons per hour, so that the towers, each of 150 tons capacity, can be at work close together or far apart discharging on to both of the wharf belt conveyors. The capacity of the belts running thence to the warehouse is also sufficient to take the combined output. These conveyors can, if necessary, also handle grain in sacks straight to or from the warehouses. The contractors for the plant were Messrs. Thomas Robinson and Sons, Limited, of Rochdale, who manufactured and supplied the mechanical conveying plant. The steel structural work of the gantries and of the travelling towers was sub-let to Messrs. Edward Wood and Co., Limited, Ordsal-lane, Manchester, while the pneumatic discharging plant on the towers, and the exhausters were supplied by Messrs. Robert Boby, Limited, of Bury St. Edmunds, who are associated with Messrs. Vickers, Limited. We shall deal first with the fixed part of the plant, namely, the arrangement of the gantries, conveyors, warehouses, &c., then taking the vacuum pumps and leaving the travelling towers for a subsequent article.

The gantry along the quay has a length of 328 ft., while that leading back to the warehouse has a length of 445 ft. These structures, as previously stated, were supplied and erected by Messrs. Edward Wood and Co., Limited. They are illustrated, the former in Fig. 5, Plate XV, and the latter in Fig. 6, while Fig. 12 herewith shows a typical cross-section at one of the larger trestles. On the wharf section the gantry consists of light girders, of 53 ft. 3 in. spans, except at the centre where junction is made with the gantry running to the warehouse, where extra trestles are introduced. In the latter gantry the spans vary very considerably owing to the necessity of clearing railway tracks, &c. Two spans are 107 ft. 7½ in. long and the underneath head room is 18 ft. on this section, against 16 ft. 6 in. at the wharf gantry. The trestles, one of which is illustrated in Fig. 12, have, in the case of the larger gantry, a spread at the base of 17 ft., between the centres of the legs, reduced to 9 ft. 2½ in. at the top. They are for the most part made up of 10-in. by 5-in. rolled steel joists for the legs, with 3-in. by 3-in. by ⅜-in. bracings, except in three instances in which the legs are of 12-in. by 6-in. joists, these being for the longer spans. The trestles for the wharf gantry have a spread at the base of 10 ft. 8 in. The trestle illustrated in Fig. 12 shows the gangway for the double conveyor leading back to the warehouses. This is considerably wider in section than the gantry along the wharf which only accommodates single conveyor belts of 27 in. width. The gantry shown in Fig. 12 has a width between uprights of 8 ft. 7½ in. and a height from floor to crosstie of 8 ft. 4 in., and accommodates two 27-in. belts. The structures are covered with galvanised sheeting, and are amply provided at the top and bottom with wind bracing as the site is an exposed one. Openings with sliding doors are provided in the wharf gantry. At the point where the two gantries join, the trestles are sheeted in to form a motor house for the conveyor motors, of which there are two of 20 h.p. at this point for the wharf conveyors. Coming now to the belt conveyor plant itself, which was supplied by Messrs. Thos. Robinson, the conveyors are arranged as shown in Figs. 7 to 9, Plate XV, at the junction of the wharf belts with those leading to the warehouse. When handling sacks the wharf conveyor ends are maintained horizontal, and the sacks are delivered satisfactorily to the cross-conveyors. When, however, grain in bulk is being handled the end of the belt is raised by means of hinged frames, one of which is shown in Fig. 8. The raised position is indicated in dotted lines, and when adjusted in height in this manner the grain is discharged over the end into a hopper (shown in dotted lines) which guides it on to the cross-conveyor. The frame carries the necessary end drum and rollers, and below the belt is led off to the tensioning gear as shown. The adjustment for height is made by a crank and bevels working screws in swivel nuts on the main frame.

The grain discharged from the wharf conveyors is taken to the warehouse on two bands, 27 in. wide, running at a speed of 540 ft. per minute, worked by

Fig. 12. SECTION ON C.D. (Fig. 6.) GANTRY "B."



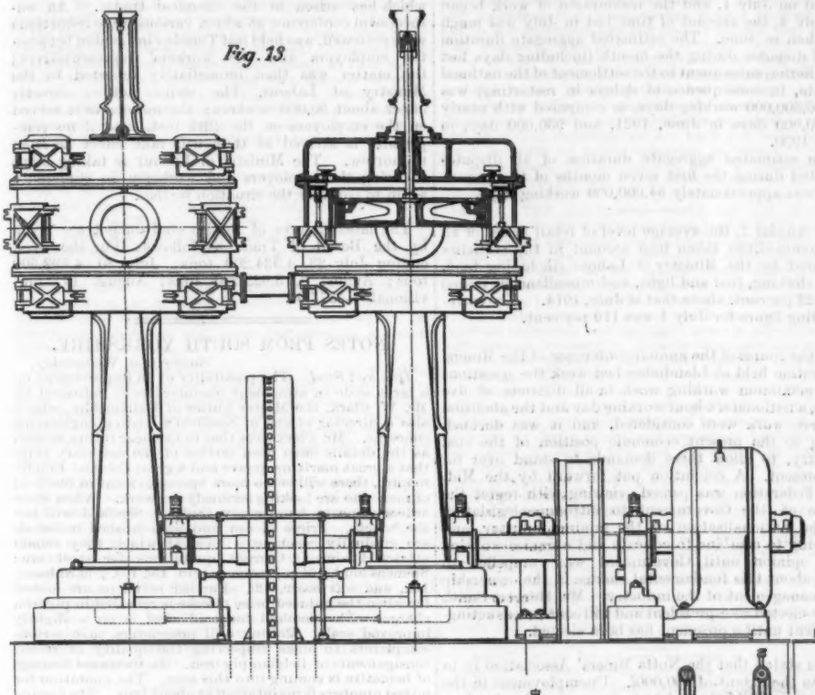
two 35 h.p. motors situated at the inshore end. These deliver bulk grain into chutes leading to the silo elevator, but when handling sacks deliver to two other band conveyors, one of which runs on under the five sheds, while the other runs under four only. These conveyors are in two sections, one inclined worked by motors of 20 h.p. and long horizontal sections passing underground also worked by 20-h.p. motors. Each shed is furnished with a conveyor running down its centre, which can be fed from the main conveyors. All these shed conveyors are driven by 20-h.p. motors, and are 22 in. wide, working at a normal speed of 200 ft. per minute. These features may all be clearly followed in Figs. 1 to 4, Plate XV.

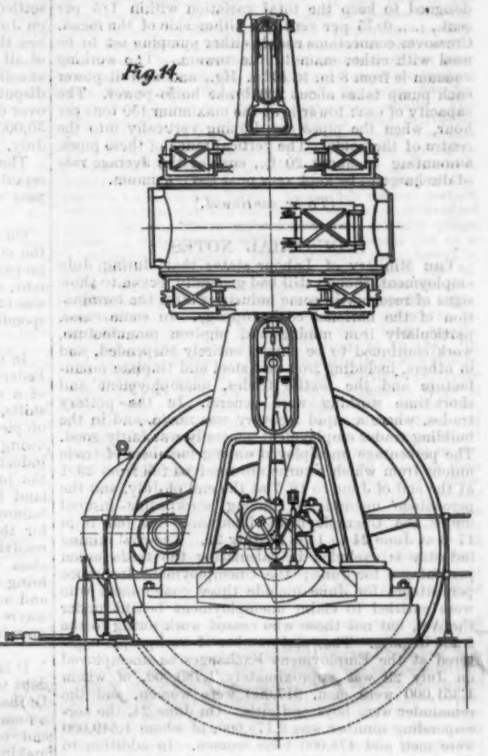
To bridge the gap between the end rolls of the main conveyors, and their continuation in the form of the inclined sections, when handling sacks which have to be conveyed to the sheds direct, an idler frame is let down into the intervening space, carrying 5-in. standard rollers. This is illustrated in Figs. 10 and 11. The frame consists of cast-iron arms with counterbalance weights, and its arrangement will be clear from our drawings without further description.

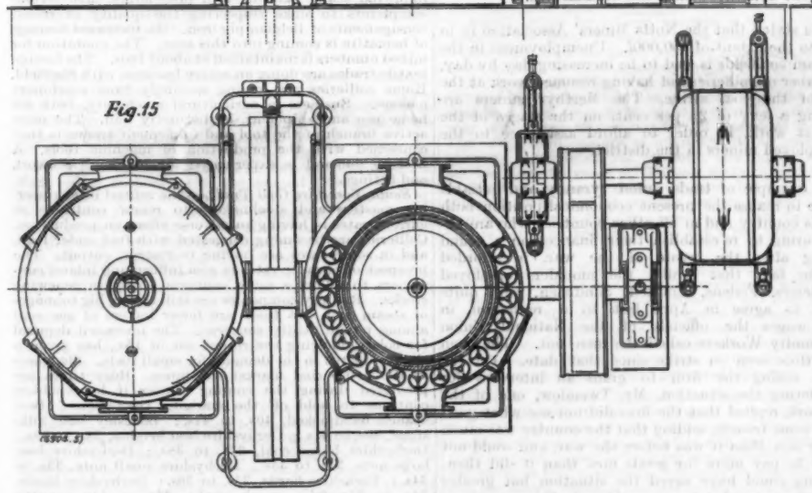
When grain in bulk is coming in on the main conveyors, on entering the warehouse it is discharged into a hopper, whence a bucket elevator working in a trunk carries it to the top of the silo building, whence it may be distributed to any of the silos. This bucket elevator is of six-ply 17-in. Balata belting fitted with buckets 16 in. by 7 in., with a pitch of 8 in. Below the silos are 27-in. band conveyors driven by 10-h.p. reversible motors, these conveyors taking grain or sacks to cross-conveyors in an extension of the second shed, from which distribution is possible to any of the sheds. As all motors are reversible, sacks can be handled in either direction, either from ship to shore and loading on the railway, or *vice versa*. When

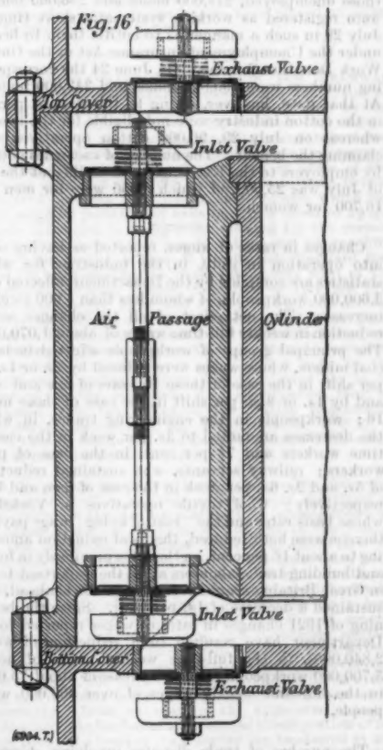
EXHAUSTERS FOR PNEUMATIC GRAIN-HANDLING PLANT AT BORDEAUX-BASSENS.

CONSTRUCTED BY MESSRS. ROBERT BOBY, LIMITED, ENGINEERS, BURY ST. EDMUNDS.









loading sacks from shore to ship use is made of a chute which is fixed to the gantry framework as indicated in Fig. 9, the sacks being discharged through openings in the gantry side. The silos are each fitted with the Pottinger distributor, which is designed so as to ensure the heavier grain being distributed round the walls and the lighter deposited in the centre. If this be done, when drawing off below, an even mixture is secured, whereas with the usual method the heavier grain discharges first, and the difference between early and the later qualities may be as much as 4·5 lb. per bushel. The Pottinger distributor consists of a box containing a screen, through which the lighter grain passes, while the heavier is delivered over the edge. The two qualities combine in a graded stream which falls over a distributor. Below each silo is fitted with a 100 kg. weigher. Fig. 18, page 316, shows a view of the ground floor of the silo house, with the weighers, and grain being sacked off. As already stated, the whole of the mechanical conveying and elevating plant, weighers, &c., was supplied by Messrs. Thomas Robinson and Sons, Ltd.

The vacuum pumps which formed part of the work supplied by Messrs. Robert Boby, Limited, consist of two electrically-driven sets of the vertical reciprocating type. Each set has two cylinders with cranks at 90 deg. They are illustrated in Figs. 13 to 16, annexed, and are also well shown in the view Fig. 19, page 316. The cylinders are 45 in. in diameter, and the stroke 20 in. The arrangement of the valves is shown to a larger scale in Fig. 16. The pistons have tail rods which work in guides above the cylinder cover. These guides with the cross-heads which work in them, are set at right angles to the main column guides and the main cross-heads. The pistons are of cast-iron, of box-pattern and fitted with a renewable solid ring. The valves are 5¼ in. in diameter. There are 17 inlet valves and 19 exhaust valves at each end of each cylinder. The inlet valve seatings are held in the cylinder casting by distance rods provided with a right and left-handed nut as shown in Fig. 16. Studs screwed into the ends of these rods form the guides for the valves and hold in place the lift plates. The exhaust valves are in the top and bottom covers. The seatings for these valves are pressed in with a slight taper fit, and are held by small grub screws. The air is drawn in through a large opening 15 in. in diameter, in the body of the casting, and on discharge from the cylinder passes into the covers, whence it is returned to a portion of the cylinder outside jacket and discharged through a central opening 18 in. in diameter.

The crosshead slippers are of cast-iron babbited, and have an area of 90 sq. in. The gudgeon pins are 3 in. by 6 in.; the main bearings are 7 in. in diameter by 10 in. wide, while the crank pins are 7 in. by 6 in.

The drive from the motors is through reduction gearing of the double helical type with staggered teeth. The large wheel on the pump shaft has 82 teeth, while the pinion on the motor shaft has 22 teeth. The teeth are of 1·5 D.P. with 13 in. face and designed for transmitting 250 brake horse-power. The motors, made by Messrs. Sandycroft, Limited, are of this horse-power, and are of the open, protected cascade induction type, with a speed of 487 r.p.m., working with three-phase 50-cycle current at 440 volts. The starters are

of the liquid type, totally enclosed, operated by worm gear.

The speed of the pumps with this drive works out at 130 r.p.m. We may add the pump flywheel is 9 ft. in diameter and has a 14-in. face. The flywheel is designed to keep the total variation within 1·5 per cent., *i.e.*, 0·75 per cent. on either side of the mean. Crossover connections enable either pumping set to be used with either main to the towers. The working vacuum is from 8 in. to 10 in. Hg., and at full power each pump takes about 220 brake horse power. The capacity of each tower is at the maximum 150 tons per hour, when the pipes are dipping vertically into the centre of the holds. The vertical range of these pipes, amounting to about 20 ft., enables the average rate of discharge to be kept very near the maximum.

(To be continued.)

INDUSTRIAL NOTES.

The Ministry of Labour states that during July employment, though still bad generally, began to show signs of recovery in some industries after the termination of the national coal stoppage. In some cases, particularly iron mining and pig-iron manufacture, work continued to be almost entirely suspended, and in others, including iron and steel and tinplate manufacture and the textile trades, unemployment and short-time working were general. In the pottery trades, where a rapid recovery was made, and in the building trades employment generally was fairly good. The percentage unemployed among members of trade unions from which returns are received fell from 23·1 at the end of June to 16·7 at the end of July, and the percentage unemployed among workpeople insured under the Unemployment Insurance Act fell from 17·8 at June 24 to 14·8 at July 29. The coal mining industry is excluded in calculating the trade union percentages for June; the Unemployment Insurance percentages for June include those coal miners who were entitled to claim unemployment benefit under the Act, but not those who ceased work owing to the trade dispute. The total number of workpeople registered at the Employment Exchanges as unemployed on July 29 was approximately 1,780,000, of whom 1,351,000 were men, 317,000 were women, and the remainder were boys and girls. On June 24, the corresponding number was 2,178,000, of whom 1,549,000 were men and 478,000 were women. In addition to those unemployed, 278,000 males and 256,000 females were registered as working systematic short time on July 29 in such a manner as to entitle them to benefit under the Unemployment Insurance Act or the Out-of-Work Donation Scheme. On June 24 the corresponding numbers were 490,000 males and 343,000 females. At that date, however, owing to the dispute, persons in the cotton industry were not eligible for the benefit, whereas on July 29, 96,000 cotton operatives were claiming the benefit. The number of vacancies notified by employers to the Exchanges and unfilled at the end of July was 25,000, of which 5,000 were for men and 16,700 for women.

Changes in rates of wages, reported as having come into operation in July, in the industries for which statistics are compiled by the Department, affected over 3,600,000 workpeople, of whom less than 5,000 received increases. The net effect of all the changes was a reduction in weekly full-time wages of about 1,070,000*l.* The principal groups of workpeople affected included coal miners, whose wages were reduced by 2*s.* or 1*s.* 5*d.* per shift in the case of those 16 years of age and over, and by 1*s.* or 8½*d.* per shift in the case of those under 16; workpeople in the engineering trades, in which the decreases amounted to 3*s.* per week in the case of time workers and 7½ per cent. in the case of piece workers; railway servants, who sustained reductions of 5*s.* and 2*s.* 6*d.* per week in the case of men and boys respectively; wool textile operatives in Yorkshire, whose basis rates and the "cost of living" wage payable thereon were both reduced, the total reduction amounting to about 16 per cent. on the rates previously in force; and building trade labourers at all the important towns in Great Britain except Liverpool and Birkenhead, who sustained a decrease of 1*d.* per hour. Since the beginning of 1921 changes in rates of wages reported to the Department have resulted in a reduction of about 2,840,000*l.* in the full-time weekly wages of nearly 5,700,000 workpeople, and an increase of about 75,000*l.* in the full-time weekly wages of over 300,000 workpeople.

The number of trade disputes involving stoppages of work reported to the Department as beginning in July was 40. In addition, 54 disputes which began before July were still in progress at the beginning of that month. The total number of workpeople involved in all disputes in progress at any time in July (including those thrown out of work at the establishments where the disputes occurred, though not themselves parties to the disputes) was about 1,127,000 as compared with 1,535,000 in the previous month, and 90,000 in July, 1920. The magnitude of the figures for June and July was, of course, due to the national stoppage in the coal mining industry. As, however, this dispute was settled on July 1, and the resumption of work began on July 4, the amount of time lost in July was much less than in June. The estimated aggregate duration of all disputes during the month (including days lost at collieries, subsequent to the settlement of the national dispute, in consequence of delays in restarting) was over 6,300,000 working days, as compared with nearly 30,000,000 days in June, 1921, and 950,000 days in July, 1920.

The estimated aggregate duration of all disputes reported during the first seven months of the present year was approximately 84,000,000 working days.

On August 2, the average level of retail prices of all the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel and light, and miscellaneous items) was 122 per cent. above that of July, 1914. The corresponding figure for July 1 was 119 per cent.

In the course of the annual conference of the Miners' Federation held at Llandudno last week the questions of a maximum working week in all districts of five shifts, a national six-hour working day and the abolition of piece work were considered, and it was decided, owing to the present economic position of the coal industry, to allow these demands to stand over for the present. A resolution put forward by the Midland Federation was passed, viewing with regret the failure of the Government to introduce legislation for the nationalisation of the mining industry, and resolving to combine to educate and organise working class opinion until Government was compelled to bring about this fundamental change in the ownership and management of the industry. Mr. Herbert Smith was re-elected vice-president and will continue as acting-president until a president has been elected.

It is stated that the Notts Miners' Association is in debt to the extent of 150,000*l.* Unemployment in the Durham coalfields is said to be increasing day by day, a number of collieries not having resumed work at the end of the coal strike. The Merthyr miners are making a levy of 2½ per cent. on the wages of the men at work, in order to afford assistance to the unemployed miners in the district.

An example of trade union tyranny and pitiable failure to realise the present economical position both in this country and in all other countries who are endeavouring to re-establish their finances on a sound footing after the waste of the war, is afforded by the fact that whilst the moulders employed by Messrs. Fodens, Limited, Sandbach, were quite ready to agree in April last to a reduction in their wages the officials of the National Union of Foundry Workers called the men out. The men have thus been on strike since that date. On the union asking the firm to grant an interview for considering the situation, Mr. Twemlow, one of the directors, replied that the firm did not see what good could come from it, adding that the country was much poorer now than it was before the war, and could not afford to pay more for goods now than it did then. Nothing could have saved the situation but greater production at such rates as would make things as cheap as they were before the war. The unions objected to the means of attaining this end, such as bonuses on output, and some went even as far as to preach ca' canny. The unions, therefore, Mr. Twemlow, further stated, by their shortsighted policy have forced upon themselves the only alternative, and that is, before trade can revive, wages will have to come down to pre-war level. This was not the desire of the firm, and as they had many times told their men, if they could sell their wagons for 3,000*l.* each they could afford to pay each man 12*l.* a week, and they would be pleased to do so. "Did it not appear farcical to the union," the director further said, "to be seriously asking for an interview to fix the men's wages when there was practically no work to be done and no wages to be paid?"

According to *The Iron Age*, New York, Pittsburgh in 1920 had 2,253 industries reporting to the Pennsylvania Department of Internal Affairs. In 1919 reports were received from 1,775. The industries last year gave employment to 118,954 persons, and in 1919 to 90,254. The persons employed in the city last year in industry included 107,922 males and 11,032 females. They were paid a total wage of $210,224,110 as compared with $117,602,200 in 1919. The capital invested in the industries of the city last year amounted to $469,286,200 against $354,042,800 in 1919. Industrial products turned out in the city last year were valued at $889,531,900, an increase of 47·6 per cent. over 1919, when the value was $602,582,800. Pittsburgh's metal products were worth $536,359,300.

We referred in our last issue to the wage difficulty which has arisen in the chemical trades. An unsuccessful conference at which various wage reductions were reviewed, was held last Tuesday in London between the employers and the workers' representatives; the matter was then immediately reported to the Ministry of Labour. The strike notices directly affect about 30,000 workers; the notices were served on the employers on the 13th inst., and if no compromise is arrived at they will take effect as from to-morrow. The Ministry of Labour is taking steps to bring the employers and workmen in conference again to consider the situation further.

The latest figures of British coal output are given by the Board of Trade as follows: For the week ending July 23, 4,334,200 tons; July 30, 4,592,500 tons; August 6, 3,623,200 tons; August 13, provisional, 4,537,300.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The possibility of an improvement on a large scale in armament manufacture is indicated by Mr. W. Clark, the Master Cutler of Hallamshire, who is also a director of one of Sheffield's leading engineering concerns. Mr. Clark says that in the near future as soon as the details have been settled of the necessary ships that a great maritime power and a great Colonial Empire require, there will be no more unemployment in Sheffield of men who are looking seriously for work. When these orders come to hand every trade in Sheffield will feel the benefit. Prices of raw and semi-finished materials are gradually reaching a level at which they should attract business. Current quotations for steel are: Siemens acid, 16*l.*; Bessemer acid, 15*l.* 10*s.*; hard basic, 13*l.*, and soft basic, 12*l.* Further revisions are looked for when the reduced price of coke is reflected in pig iron charges. The demand for acid steel is on a slightly improved scale. Rolling mill proprietors have serious complaints to make respecting the quality of recent consignments of Belgian pig iron. An increased tonnage of hematite is coming into this area. The quotation for mixed numbers is maintained at about 160*s.* The foreign textile trades are doing an active business with Sheffield. Home collieries are buying sparingly from machinery makers. Business in agricultural machinery, both for home use and shipment, is distinctly dull. The most active branch of the tool and implement trades is that concerned with the production of machine tools. A healthy demand is experienced for builders' ironwork and fittings.

South Yorkshire Coal Trade.—The refusal of engineering masters and steelmakers to renew contracts at current rates is having an adverse effect on production. Collieries are becoming congested with fuel under load, and in some cases are having to restrict output. The prospect of cheaper rates is also influencing inland consumers to adopt a more cautious policy in renewing stocks. Railway companies are still taking big tonnages of steam fuel, but there are fewer buyers of gas coal among public utility concerns. The increased demand for coke, following the recent cut of 15*s.*, has given a slight impetus to the demand for small fuels. Slackness in the house coal market continues. Busy times are predicted during the coming winter if householders continue to hold off the market. Quotations: Best branch handpicked, 40*s.* to 41*s.*; Barnsley best Silkstone, 40*s.* to 41*s.*; Derbyshire best brights, 38*s.* to 39*s.*; Derbyshire house coal, 37*s.* to 38*s.*; Derbyshire best large nuts, 34*s.* to 35*s.*; Derbyshire small nuts, 33*s.* to 34*s.*; Yorkshire hards, 35*s.* to 36*s.*; Derbyshire hards, 34*s.* to 35*s.* 6*d.*; rough slacks, 22*s.* to 24*s.*; nutty slacks, 20*s.* to 22*s.*; smalls, 13*s.* to 16*s.*

SUEZ CANAL TRAFFIC.—A statement giving particulars of traffic through the Suez Canal in 1919 has just been published although it was prepared as far back as April of last year. From this we learn that 3,986 vessels, with a total net tonnage of 16,013,802, passed through the canal during the year under consideration, and that 70·9 per cent. of this tonnage was of British nationality. Japanese vessels accounted for 9·1 per cent. of the total tonnage, Dutch vessels for 4·7 per cent., and French vessels for 3 per cent. As would be expected the year was exceptional on account of the large volume of traffic due to the repatriation of troops, 386 warships and transports passing through the canal as well as 752 vessels under Government charter. These vessels together accounted for 4,266,940 net tons or nearly 27 per cent. of the total. Of the remainder, 2,068 with a total tonnage of 8,542,596 were merchant vessels; 303, totalling 1,525,139 tons, were mail steamers, and 477, making 1,679,127 tons, were vessels in ballast. The nature of the traffic is also indicated by the fact that of the total number of passengers carried on vessels passing through the canal, 394,224, or 75 per cent., were military 129,477 were civil, and a further number of 3,801 were classified as "special," the total thus amounting to 527,502. Vessels navigating by night and day took an average time of 15 hours 33 min. for the passage through the canal, while the corresponding figure for those navigating by day only was 21 hours 53 min. The total receipts for the year amounted to 144,983,678 fr., or 8·5 fr. per net ton of shipping using the canal.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig iron is still very quiet. Though only one firm is making No. 3 G.M.B. for sale in the open market, supply is quite sufficient to meet the meagre demand. The price of the ruling quality remains at 135*s.* There is no No. 1 Cleveland or siliceous iron to be had. Foundry 4 is fairly plentiful, and is offered rather freely at 125*s.* or 5*s.* below the figure at which it has been quoted for some time past. The inferior grades are quite a drug on the market. Makers experience much difficulty in inducing customers to reduce stocks by making purchases at 117*s.* 6*d.* for No. 4 forge and mottled, and 115*s.* for white iron.

Hematite.—With two furnaces now producing hematite there is rather more of that commodity available for sale, but supply is none too plentiful. For home purposes No. 1 is 162*s.* 6*d.*; and Nos. 1, 2 and 3 are 160*s.* These rates also rule for shipment abroad though it is still possible to place export orders at a little below home quotations.

Foreign Ore.—So far as is ascertainable no effort is being made in the direction of resumption of business of any importance in foreign ore. Consumers' stocks are heavy, and there are still large deliveries to be made against old contracts.

Coke.—As was anticipated coke is falling rather rapidly. Whilst some firms are inclined to hold out for more no difficulty is experienced in purchasing Durham blast furnace kind at 35*s.* delivered. Local consumers consider the price should not be more than 30*s.*, and there are rumours that it can be bought at near that figure.

Manufactured Iron and Steel.—New finished iron and steel orders are very difficult to secure. Works are only moderately employed, and some are shut down altogether. A fall of 40*s.* in boiler plates and 20*s.* in ship plates, angles and joists is only what was anticipated. Principal market quotations stand: Common iron bars, 16*l.*; market bars, 20*l.*; steel billets (medium), 12*l.* 10*s.*; steel billets (hard), 13*l.*; steel boiler plates, 19*l.*; steel ship, bridge and tank plates, 14*l.*; steel angles and joists, 13*l.* 10*s.*; tees, 14*l.* 10*s.*; rounds and squares, 13*l.*; flats, 14*l.*; heavy steel rails, 14*l.*; fish plates and sleepers, 19*l.*; black sheets, 17*l.* 10*s.*, and corrugated galvanized sheets, 21*l.* 10*s.*

PERSONAL.—We understand that Messrs. Manning, Maxwell and Moore, Incorporated, 119, West 40th Street, New York, N.Y., U.S.A., are now represented in this country by Mr. F. E. Bayley, A.M.I.E.E., whose office is No. 1, Lincoln's Inn-fields, London, W.C.2.

FREE BRITISH PROPAGANDA AT THE TRIESTE SAMPLES FAIR.—The authorities of the annual Trieste Samples Fair, which opens on September 11, have invited H.M. Government to form a British propaganda and information bureau at the fair. The stand has been placed at the disposal of the British Consul-General free of charge, and the organisation of the bureau has commenced. Trade catalogues, photographs and general literature will be displayed on the stand and information supplied in response to commercial inquiries. There will be no expense to United Kingdom firms whose literature is displayed at the propaganda bureau apart from the cost of forwarding it to Trieste. Further information should be applied for immediately at the Department of Overseas Trade, 35, Old Queen-street, S.W.1.

THE LATE MR. JOHN HENRY DEWHURST.—We regret to have to announce the death, which occurred recently at his residence, Beechy Knowle, Richmond, Sheffield, of Mr. John Henry Dewhurst, chairman and managing director since 1902 of the Dewhurst Engineering Company, Limited, Sheffield. Mr. Dewhurst was born in Manchester in 1854, and was educated in Sheffield. He received his engineering training with various firms in Sheffield and in Manchester, and was subsequently engineer and chief engineer of various iron and steel companies, down to 1891. In the latter year, he joined his father's business, the firm being John Dewhurst and Son until 1902, when it was converted into a limited company. He was the designer and patentee of the "Dewhurst" system of slag ladles and cars and other steelworks plant. Mr. Dewhurst was a member of the Institution of Mechanical Engineers since 1895, and since 1903 a member of the Iron and Steel Institute.

THE TESTING OF FUSION WELDING.—In the course of an article on the possibilities of fusion welding, *The Iron Age*, New York, states that a number of ideas have been suggested for the testing of welds. Some shops require their welders to make sample welds each month, these are tested and the results posted on a blackboard for all the shopmen to read. This has both its advantages and disadvantages. Another plan is to cut out a section of a weld where this is practicable, and to examine it for fusion and porosity. If the welder does not know just when his work is to be tested he is likely to be forced to constant care. There are cases where welders are required, after making a good sized weld, to stamp their initials and the date alongside of the job so that there can be no question as to responsibility of workmanship if the weld fails. The testing of welds is a matter of vital importance, and it is of interest to learn that a special committee of the American Welding Society is devoting considerable attention to the question at the present time.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—There has been little or no improvement in the state of trade in general throughout the country during the past few weeks, and the future is somewhat obscure in the meantime. The holidays in the manufacturing districts are mostly finished now, but in few instances has the restart been a very active one, because of the poor state of order books. Conditions all over are rather unsettled and no buying movement or even inclination to buy is noticeable. The great demand is for lower prices, but labour, naturally desirous of selling its goods in the dearest market, is unwilling to accept any reductions proposed in wages, and so selling departments are hard put to it to offer their products at prices agreeable to buyers, when, in so many cases, the foreigner is able to underquote at several pounds per ton. The Scottish steel makers have taken 1*l.* per ton off their prices, but iron is still unchanged. The engineering works are not, over all, busy and a reduced working week is still fairly general, and the same applies to the shipbuilding industry. One rather bright feature in connection with the latter is that the joiners having settled their difference, are returning to work this week, after a strike which has lasted since last December. During those nine months, much fitting-out and repair work has been lost to Scottish shipyards and the Clyde firms in particular have suffered rather severely. Textile firms are moving very slowly, and generally the trade outlook is far from reassuring. With the official termination of the war at the end of this month, the Ministry of Munitions' 12½ per cent. war bonus will probably be taken off workers, and manufacturers will be placed in a better position to shade prices and encourage business. Fuel has eased in price, but the demand from industrial concerns, as well as from householders, is so small that many pits are only working a part of the week, and stocks at the pit head are increasing. A further fall in prices is expected shortly, and this will greatly assist business.

Scottish Steel Trade.—The only item of any note in connection with the Scottish Steel trade this week is the intimation by makers of another reduction of 1*l.* per ton in prices. The last reduction about a couple of months back was not very fruitful, and the foreigner continued to pick up the most of the business passing, with the result that since the works were reopened a few weeks ago, there has been very little doing. The new level to which prices have been brought is in the hope of inducing the home buyers to place locally some of the orders they have on hand, but the difference between these quotations and those of the Continental producer is still too large to hope for any big buying movement at present. Order books are very bare and the various establishments are not being kept in full operation, so poor is the current demand for all classes of material. The new quotations are as follows:—Boiler plates, 19*l.* per ton; ship plates, 14*l.* per ton; and angles, 13*l.* 10*s.* per ton; all delivered at Glasgow stations, and subject to the usual extras. Makers of steel sheets are finding things a trifle stiff at present largely owing to keen competition from the Continent, and little fresh business is being booked, but there are a few export orders in the market.

Malleable Iron Trade.—The manufacture of malleable iron in the West of Scotland is of very small proportions at the present time as the demand is not heavy. The figure which the local makers require on account of the high cost of production is all against any opening out of business, and until lower quotations are possible, flat conditions are likely to continue. "Crown" bars are quoted round 16*l.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—The conditions in the Scottish pig-iron trade have varied very little of late, and although some of the blast-furnaces have been rekindled, the production overall is still very small. The position with regard to foundry iron is slightly improved but there is still a scarcity. Inquiry is slightly better, but the actual demand has not improved to any extent. Prices show no change, but forward rates are inclined to be softer, which would tend to the belief that easier quotations may be expected at no distant date.

The Ship Joiners' Strike.—Reports to hand from the Clyde shipyards to-day show that the joiners who have been on strike since December 1 last, made a very satisfactory start this morning. The total number who went on strike was round about 4,000, and of that number something like the half of these obtained employment elsewhere, but a very large proportion presented themselves at the gates this morning being eager to return to their old jobs. There is quite a lot of fitting-out work to commence to, and many other tradesmen who were affected by the joiners being on strike will once again obtain employment.

THE SHRAWARDINE TRIALS OF AGRICULTURAL TRACTORS.—The annual tractor trials of the Society of Motor Manufacturers and Traders will be held this year at Shrawardine, about six miles from Shrewsbury, during the five days September 20 to September 24 inclusive. Shrawardine is reached from Shrewsbury by a local train service, and, in addition, the Midland Motor Omnibus Company, Limited, are running a special quarter-hour 'bus service from Shrewsbury to the ground. Competitors are restricted to the entry of two machines only of any one make or type, but even so, 37 tractors are entered. In addition to these, 25 special implements have been entered for test and report. There is also to be an extensive exhibition of power farming machinery, the entries for which are not yet complete.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Though the tentative inquiry has broadened and inquiries are more numerous, actual business remains very restricted, as buyers continue to follow a hand-to-mouth policy. In fact, most of the inquiries about are considered more as feelers and unlikely to lead to definite business. Important negotiations in respect to arrears and balances of Italian contracts have been concluded. At the end of last year contracts were made for 1921 delivery at prices ranging from 90*s.* to 97*s.* 6*d.* per ton f.o.b. for large, 85*s.* for through, and 60*s.* to 65*s.* for best steam smalls. The three months' coal strike interrupted these deliveries, while prices have materially fallen since these contracts were arranged. It has now been mutually agreed to deliver the balance up till the end of the year, which involves over 500,000 tons, on the basis of 40*s.* to 45*s.* per ton f.o.b. for best large. Meanwhile current market values are irregular and entirely dependent on individual circumstances. It is very difficult to actually gauge prices as only buyers with definite business are in a position to test values. Best Admiralty large, however, range from 34*s.* to 35*s.*; second Admiralties, 31*s.* 6*d.* to 32*s.* 6*d.*; best Monmouthshire large, 30*s.* to 32*s.* 6*d.*; best dry large, 33*s.* to 35*s.*; and ordinary dry large, 30*s.* to 32*s.* 6*d.* Best steam smalls are from 18*s.* to 19*s.* 6*d.*; ordinaries, 16*s.* to 17*s.* 6*d.*; cargo smalls, 12*s.* 6*d.* to 15*s.*; and dry smalls from 9*s.* to 12*s.* In the bituminous section, No. 3 Rhondda large and smalls, which are a market on their own, are worth respectively round 47*s.* 6*d.* and 30*s.*; but No. 2 Rhondda large is round, 30*s.*; throughs, 20*s.* to 24*s.*; and smalls, 16*s.* to 18*s.* Patent fuel is weaker, at 32*s.* 6*d.* to 35*s.*, and pitwood has dropped from 37*s.* 6*d.* at the beginning of the week to 30*s.* Foreign cargo exports of coal in the past week totalled 300,000 tons, or 6,000 tons less than the previous week's record quantity for this year. Shipments from Cardiff at 213,000 tons established a record for the year. Exports to South America at 41,000 tons were also the highest for any single week this year. The British coaling stations also took a record quantity with 60,000 tons. Patent fuel exports totalled 34,000 tons, the highest for the year, and the bulk of this was sent from Swansea, which port shipped 22 cargoes, totalling 26,000 tons, to 18 different destinations.

Iron and Steel.—Recent inquiries, which it was hoped would have been the forerunner of a revival in the tinplate trade, have not matured into actual business. In consequence, sellers have again become pessimistic. In fact, mills which had re-started have been compelled to close for want of orders. At present outputs represent only about 25 per cent. of the normal. Prices range from 22*s.* 6*d.* to 24*s.* 6*d.* for standard boxes. Sheet and tin bars are unchanged at 8*l.* 10*s.*, with the general position dull. Belgian bars are lower at 6*l.* f.o.b., and it is reported South Wales buyers have placed an order for 30,000 at a lower figure.

BRITISH STANDARD SPECIFICATION FOR TRAMWAY TYRES.—A British Standard Specification for Tramway Tyres (No. 101, 1921) has now been published by the British Engineering Standards Association. In this the profile of tread and flange originally standardized and issued in the British Standard Specification for Tramway Rails in 1903, has been retained, but in place of the varying widths of tyre then provided to suit the British Standard Sections Nos. 1 to 5, one uniform width has been adopted suitable for rails having a tread of 2½ in., which dimension is being recommended for the revised rail sections now under consideration and approaching issue. This width is that of the British Standard Section No. 4, probably the most extensively used of the Standard Sections. Three diameters of tyre are provided for, namely, 32 in. and 33 in., for tramway driving wheels and 22 in. for pony truck wheels. A plate attached to the specification gives the finished sizes and the rolling allowances for machining. Metric equivalents of the British measures are given, but a note to the specification makes it clear that the latter are to be regarded as the standard. The specification may be obtained from the offices of the British Engineering Standards Association, 28, Victoria-street, S.W.1, or from Crosby Lockwood and Son, Stationers' Hall-court, E.C.4, price 1*s.* 2*d.* post free.

A VARIABLE PLATINUM RESISTANCE.—The following arrangement of a variable resistance is described as preferable to the ordinary slide wire arrangement by O. Maass and C. H. Wright, of Toronto, in the journal of the American Chemical Society of May last. A platinum wire is vertically stretched in a glass tube, 1 cm. or 2 cm. in diameter; the wire is sealed in at the top and bottom of the tube with the aid of special cement. The lower end of the tube communicates by a bent branch tube with a closed bath of mercury of greater volume than the tube. From this bath rises another vertical smaller glass tube which has itself several horizontal branches; the first leads to a large bulb, the second is a capillary, the third uppermost branch is fitted with a tag and is bent down and up again, being open at its extremity. After evacuating the apparatus mercury is distilled into the basin and into the lower portion of the wire tube; the level of the mercury can be altered at will and the resistance of the platinum thus be varied. The platinum wire remains always in the vacuum, and the ordinary fluctuations in the contact resistance are eliminated. The wire used has a length of 50 cm. and a resistance of 1 ohm. and 0·2 mm. of platinum correspond to 0·002 ohm. After using this resistance for eight months Maass and Wright found that the platinum resistance had not changed by more than 0·001 ohm.

GRAIN-DISCHARGING AND SACK-HANDLING PLANT FOR THE UNION COMMERCIALE DE BORDEAUX-BASSENS.

(*For Description, see Page* 312.)

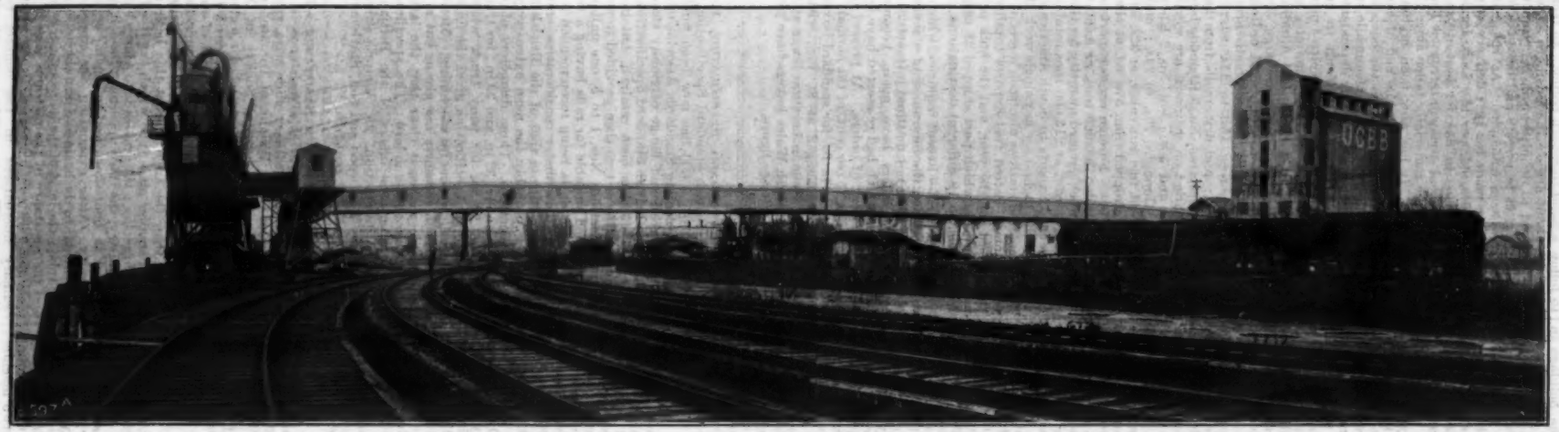


FIG. 17. GENERAL VIEW OF PLANT, SHOWING THE TRAVELLING TOWERS, GANTRIES AND SILO BUILDING.

FIG. 18. INTERIOR OF SILO BUILDING: GRAIN BEING SACKED OFF WITH AUTOMATIC WEIGHERS.

FIG. 19. THE ELECTRICALLY-DRIVEN EXHAUSTERS OR VACUUM PUMPS.

PNEUMATIC GRAIN-DISCHARGING AND SACK-HANDLING PLANT FOR TH

(For Descrip Page 312

2 Travelling Pneumatic Grain Suction Plants each 150 Tons per Hour

Fig. 1. SECTION OF CONNECTING GANTRY B.

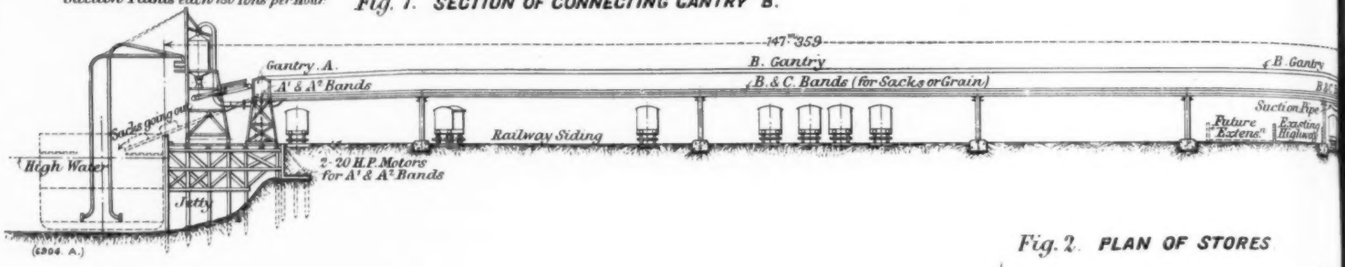


Fig. 2. PLAN OF STORES

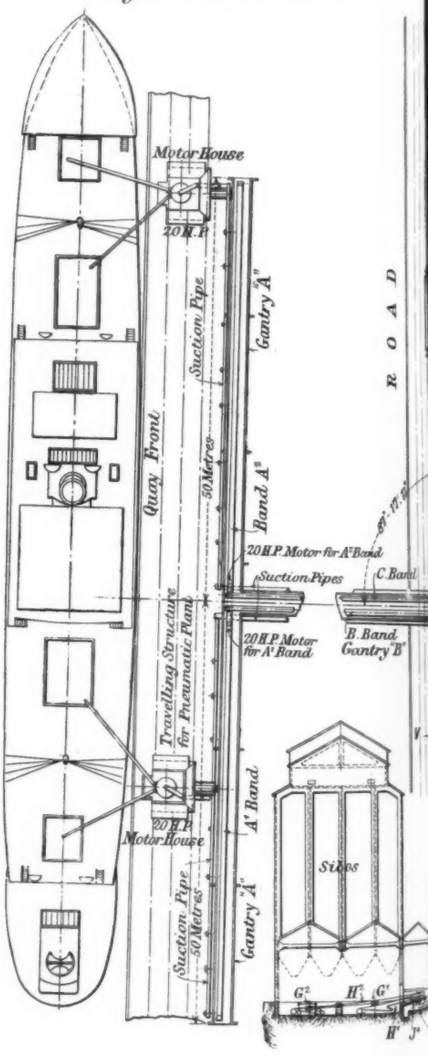


Fig. 7

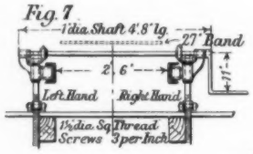
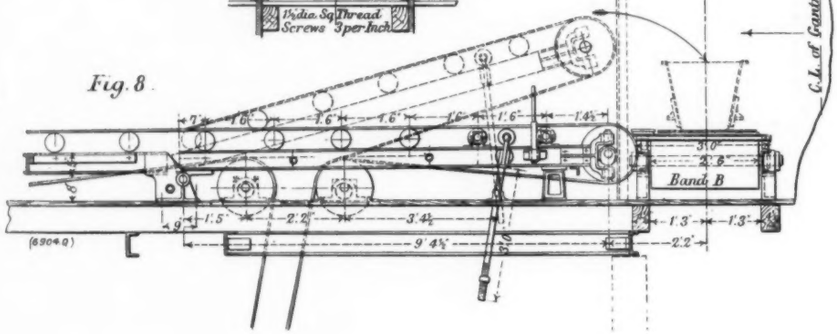


Fig. 8.



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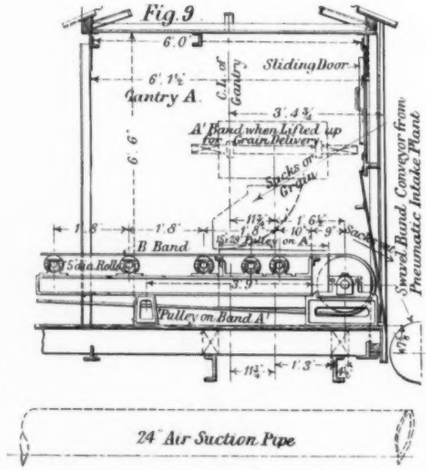


Fig. 10.

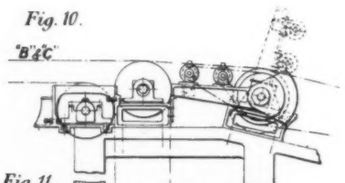


Fig. 11.

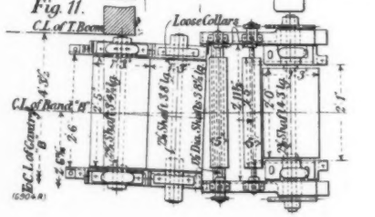
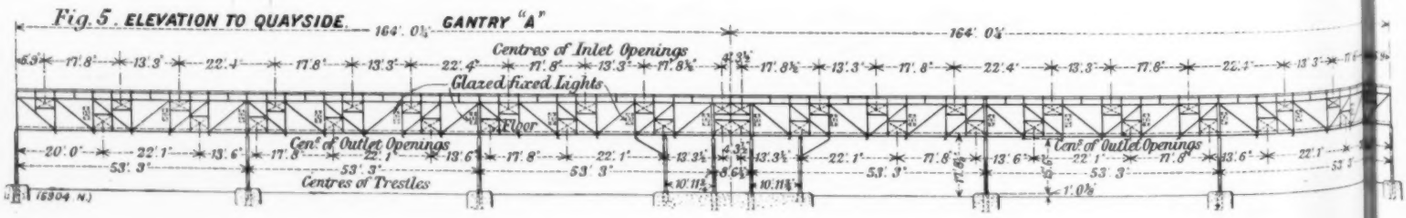
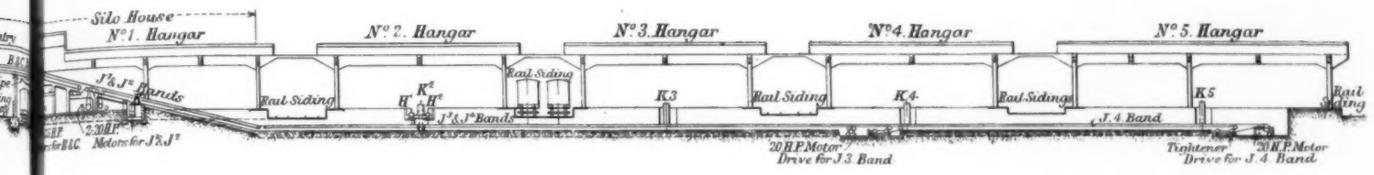


Fig. 5. ELEVATION TO QUAYSIDE. 164' 0½" GANTRY "A"



THE UNION COMMERCIALE DE BORDEAUX-BASSENS, FRANCE.

(See Page 312.)



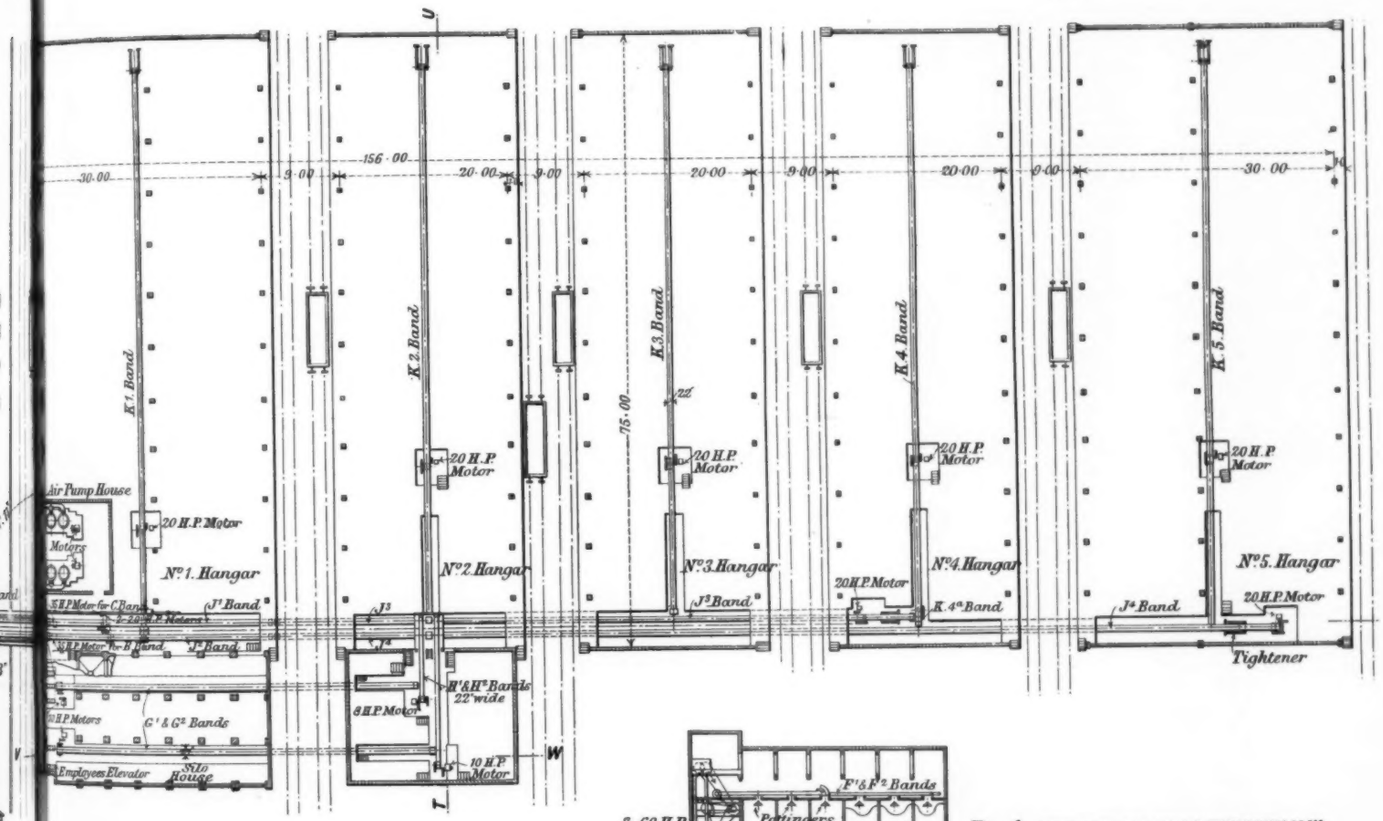
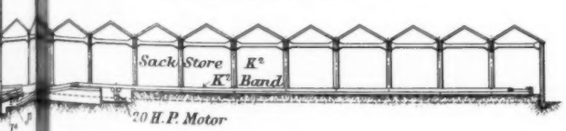


Fig. 3 SECTION OF HANGER THROUGH T.U.



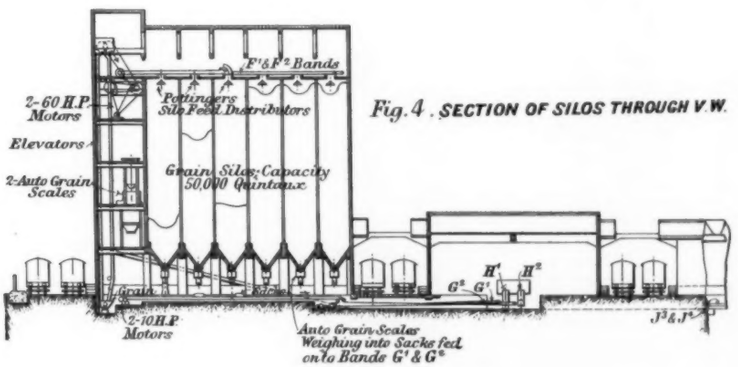
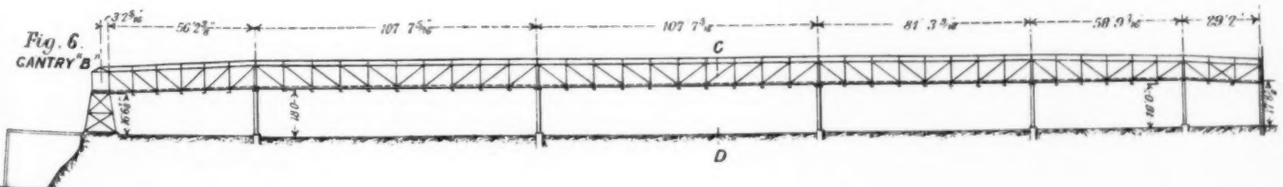

F¹ & F² Bands
2-60 H.P. Motors
Elevators
2-Auto Grain Scales
Grain Silos; Capacity 50,000 Quintaux
2-10 H.P. Motors
Auto Grain Scales Weighing into Sacks fed on to Bands G¹ & G²
J³ & J⁴

Fig. 4. SECTION OF SILOS THROUGH V.W.



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ADVERTISEMENT RATES.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

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Thick paper copies	£3 3 0
For all other places abroad—	
Thin paper copies	£3 3 0
Thick paper copies	£3 7 6

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C.2.

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TELEPHONE NUMBERS—3663 and 8398 GERRARD.

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With a Two-Page Plate of the PNEUMATIC GRAIN-DISCHARGING AND SACK-HANDLING PLANT FOR THE UNION COMMERCIALE DE BORDEAUX BASSENS, FRANCE.

ENGINEERING.

FRIDAY, AUGUST 26, 1921.

BRITISH REPRESENTATION ABROAD.

DURING the years of the war our engineering shops were filled with work of such immediate urgency that not only had the normal export trade to be for the time forgotten, but overseas offices were closed and foreign connections abandoned in the concentration of effort which the times demanded. Now that the world trade is once more being reorganised on a peace basis and in accordance with the changed political conditions which the war has brought about, it is well for the British manufacturer to review the situation carefully and consider what steps he should take to re-establish his position. Matters are by no means where they were left in 1914. Foreign customers have been forced to find alternative sources of supply, and trade rivals have established themselves in markets once almost entirely held by British manufacturers. The impossibility, moreover, of obtaining even spare parts of machines from England, during the war has in many cases resulted in grave inconvenience to users of British machinery, and has caused a prejudice against dealing with a far-off country which has been cultivated for all and more than it is worth by competitors whose works were nearer the customer.

British trade abroad has now to be built up again, and the opportunity should be taken to reconstruct it on much more effective lines than in the past. Everyone who has had an opportunity of studying British trade from the standpoint of an overseas consumer, knows how deplorably many of our manufacturing firms mishandled their opportunities before the war. Not only did they show no energy in securing trade, but even in cases where a buyer, influenced by favourable knowledge of British machinery, and possibly also by a sentimental attachment to the "Old Country," has placed inquiries with them, their methods of dealing with such inquiries have often been such as to make business practically impossible. Prices quoted "f.o.r our works, packing for shipment extra," or even "f.o.b. Liverpool or equal" are very little use to a man on the other side of the world with no means of finding out freights and duties. Quotations in sterling to a customer who keeps his books in another currency are almost equally futile and irritating. To tell a buyer in Canada, for example, that the machinery he wants will cost him 10,000*l.* f.o.b. Liverpool, is practically to inform him that his order is not considered worth the trouble of quoting properly for. The American, German or Swiss manufacturers will tell him, as a matter of course, exactly what he wants to know, namely, how many dollars he will have to pay for the machinery delivered in his own town. Somebody has to take the trouble of finding out freight rates and duties, and somebody has to bear the risk of a fluctuating exchange. This somebody must be the manufacturer, if he is quoting in competition, for when all is said and done the buyer is master of the situation, and, other things being even approximately equal, he will place his order with the firm that makes it easiest for him to do business.

To conduct an effective overseas business, it is, however, absolutely necessary to have some responsible representative on the spot whose duty it is to keep in touch with prospective buyers, obtain inquiries and follow up tenders. In this respect many British firms have been deplorably lax. They have entrusted their interests too often to some agent in the country, known to them perhaps only by correspondence, and without either the technical knowledge or the authority to negotiate any important contract. The territory allotted to him, although not looking impressively large in the map of a continent, may be thousands of square miles in extent, and the distances between the important towns so great that the time and expense of travelling across the country is quite prohibitive in the case of all but the largest contracts. Under such conditions it is not surprising that numerous openings for the firms' products are never heard of, nor that many an order is lost because the inquiry could not be properly followed up. A certain number of orders will, of course, be booked annually, and the home firm complacently congratulates itself upon the trade it is doing in that country, never realising that ten or twenty times as much business could be obtained were its representation more efficient.

A method adopted by some manufacturers, is to come to an arrangement with a firm of machinery agents abroad whereby the latter take into their employment an engineer from the manufacturers' works, whose primary duty it is to look after the interests of the home firm and to deal with all business concerning their products. This enables the home firm to take full advantage of the local knowledge of the agents, and at the same time to feel sure that technical matters are competently handled. An engineer sent abroad in this manner will probably be listened to when he recommends certain modifications of design or variations of practice to suit the special requirements or prejudices of customers in that part of the world. He can give his principals valuable information as to impending contracts, and keep them advised of the general trade conditions. He becomes, indeed, if he is the right sort of man, an exceedingly valuable outpost of the home establishment, both technically and commercially. The local agents, on their part, benefit by his success, and the arrangement should be satisfactory to everybody concerned. The proper type of man is, however, essential and even if such men were commoner than they are, the employment of them in the manner indicated would only be possible to a comparatively few manufacturers, because a limited number only can be absorbed by overseas agents.

The most effective representation of all is for the home firm to open an office in its own name, and put this in charge of a responsible practical engineer, who can devote his whole time to the development of the firms' business. The moral advantage of "a local habitation and a name" in conducting business abroad is very great, as the customers feel that they are dealing as directly as possible with the firm itself, and will receive first-hand information and advice from someone competent to give it. An overseas office should always have at its disposal at least one first-class mechanic, preferably trained in the manufacturers' works, who can go to any part of the territory for the erection or repair of the firm's machinery, or to rectify any causes of complaint. Many a machine installed overseas gets a bad name for itself and its makers, simply because it is badly erected or operated. Few firms realise how much they owe, for good or bad, to their erectors abroad. Such men come naturally into intimate contact with the customer and his operating engineers, and prospects of future business will depend very largely upon the impression of the firm which is unconsciously conveyed by the erector. If he is competent, quick, and can gain the respect and liking of the purchaser of the machinery and his staff, a very great deal has been done towards booking further orders in that part of the country. Conversely, an incompetent or disagreeable man will do the goodwill of his employers a vast amount of harm. To imagine, as some erectors sent out from England appear to do, that their knowledge is so immensely superior to that of the local engineers, that they can afford to ignore all advice and despise the warnings of experience, earns the contempt that they deserve, not only for themselves, but for their firm. They should realise that men who operate plant in the wild places of the earth are of necessity men of capacity, or they could not do it at all, and furthermore such men may have had in their youth a sounder mechanical training and a better education than the erector himself could lay claim to. An erector's job abroad is not one to be entrusted to some young man who has a "pull" at the works, and who anticipates a pleasant holiday. It should be reserved for the very best and most trustworthy practical man available, even if only for the good impression of the firm that such a man will create among the people with whom he is brought into contact.

Inextricably bound up with the sale of machinery abroad is the question of repairs and spare parts.

Every foreign traveller, when seeking an order, must have been met with the question of when and how soon spare parts can be obtained in the case of breakdown. It is no use to reply, even if it is practically true, that a breakdown is not to be anticipated. The buyer knows, often from sad experience, that the most unlikely accidents may happen, especially to machinery operated by unskilled and somewhat reckless labour. He thinks it unreasonable that he should be expected to stock a complete set of spare parts himself in readiness for every possible contingency, and he is uncomfortable at the prospect of having to send to England for them if wanted. This would generally mean many months of delay and the possibility of all kinds of misunderstandings and mistakes. It is, therefore, essential, if overseas trade is seriously contemplated, that spare parts should be available in the country in which the machines are working. If the buyer knows that they actually exist on his own side of the ocean, even though they are still a thousand miles or more from his works, he feels comparatively safe, knowing that they can be forwarded by express in response to a telegram. The expense of stocking spare parts, and even machines of small or standard type, in a distant country, is very small indeed compared with the benefits of having such a stock on the spot. Not only are prospective buyers re-assured, but many an order for new plant can be obtained if instant delivery can be given. The overseas buyer, owing to the shortness of his working season or to the rapidity of some development, often wants machinery in an extreme hurry. He will accept anything which will do the job rather than wait, and will not hesitate about price if the machine can be put on rail right away.

To revert to the case of the manufacturing firm which entrusts its foreign interests to the care of an agent, overseas buyers often express astonishment at the kind of agent in whom some British firms will place their confidence. An incompetent or unscrupulous agent is so detrimental a representative that unless a firm can spare some responsible member of the staff to make investigations on the spot, the services of the local British Trade Commissioner should be invoked. The Trade Commissioners have special facilities for obtaining knowledge, and much invaluable advice is freely at the disposal of any British firms who will take the trouble to ask for it. Firms who ignore the assistance offered by the Government in the matter of protection against unsuitable agents have only themselves to blame if the arrangements they enter into turn out to be unsatisfactory. The best agent in the world, however, cannot develop trade unless his efforts are properly seconded by the home firm, who must honour his promises and permit him a reasonable latitude in making them. He is bound to be better informed as to the conditions of the local market than they can be, and his advice ought never to be ignored, except for imperative reasons. Finally, an agent is worthy of his hire, and his commission should be liberal, especially during the first years when work is entailed in getting every order. Some firms, very wisely, arrange in their agreements with agents, that the commission shall commence at an exceptionally liberal rate, and shall be reduced year by year in accordance with the presumably less work and expense required to obtain orders.

FUTURE NAVAL POLICIES.

Towards the end of April last, the French naval journal, *Moniteur de la Flotte*, invited French naval officers of all ranks who took part in the late war to set forth their views as to the perspective from which future wars on sea would have to be considered, prominence to be given particularly to the naval policy to be adopted by France, and also to the methods and arms by means of which they considered that policy should be carried out. A number of contributions were received, and our contemporary has published several of them. We propose to give in the present article a brief abstract of the views expressed therein. It may be stated in the first place that, as was to be expected, no definite programme can be evolved on the basis of these contributions, none of the writers having presumed, and very rightly so, to possess what we may term a panacea capable of meeting all the eventualities likely to arise. Moreover, in the case of France, as in that of those other nations whose finances have been depleted by the gigantic struggle which was thrust upon civilisation by Germany, and from which the world has only recently emerged, a future naval policy is bound up with financial limitations, and this fact acts as a very effective check even upon the expression of a mere opinion as to any future policy, whether concerning naval enterprise or any other kindred undertaking.

As was to be expected also, and as we fully anticipated when we were first aware of our contemporary's intention, practically every writer whose contribution we have seen lays special stress upon the very great value of aircraft and upon the effective part this is sure to play in any future naval conflict. One of the French naval officers expresses the opinion that aeronautics has become "a naval force," which France should develop actively, since it can contribute to her military power and, in peace time, contribute also to her economical life by furthering commercial intercourse between the metropolis and the French colonial possessions. In his view, aeronautics may even become the most important branch in the Service of any nation. This fact, quoting the same expert, has even now been most clearly recognised by Germany, the "eternal nation of prey," who, under the pretext of establishing regular postal and commercial communications by air, is now building a powerful fleet of aircraft capable of being enlarged by thousands of units in a few weeks only of industrial mobilisation for war.

In regard more particularly to naval ships, whilst every writer very justly advocates for France the formation of a fleet commensurate with her standing as a great Power, her extensive coast line on the Atlantic Ocean and on the Mediterranean, and her commerce and colonies, varying opinions are expressed as to what should be the composition of such a force. One French officer defines the duty of the French Navy as follows:—(*a*) Coast defence; (*b*) the cutting-off of enemy supplies; (*c*) the protection of French convoys; and (*d*) the attack on the enemy's coasts and territory. Coast defence would be effected by every available signalling means, including aircraft, by long-range guns mounted on land batteries, by land torpedo batteries, mine laying and mine sweeping ships. The attack of enemy convoys would be entrusted to blockading submarines of average size and average surface speed, armed with guns and torpedo-launching tubes, aided by light cruisers of about 7,000 tons displacement, having a very high speed, excellent seagoing qualities and a large radius of action, these light cruisers being armed with two large calibre guns, carrying a scouting aeroplane and fitted with a powerful wireless telegraphy installation. As regards the French convoys, these could be protected by large cruising submarines having a displacement of 3,000 tons and a surface speed of 18 knots, aided by light cruisers. There would be held in reserve, to await the time for acting under the most favourable conditions against all or part of the enemy's forces, a battle fleet formed of a number of battleships armed with the greatest possible number of 400-mm. (15¾-in.) guns consistent with a displacement of 25,000 tons to 30,000 tons. Range-finding on board the battleships would be assisted by aircraft, and scouting would be carried out by submarines, dirigibles, seaplanes and cruisers. Destroyers would accompany the battleships. Attacks on the enemy's coasts and territory would be entrusted to the air fleet. This same officer, when referring to the German submarines which were present at the Jutland Battle, states that the part these craft played on that occasion was an insignificant one, although about 100 British surface ships were concentrated in waters easy of access; he adds that the circumambient character of a naval engagement, where clear vision and rapid manœuvring are essential, is unfavourable to the action of submarines. The inferiority of this type of craft lies in its low speed when submerged, and there is, in this same officer's opinion, but little improvement to be expected in this connection.

In the matter of surface ships, these are obviously necessary, according to most of the contributors to the discussion whose replies were printed by our contemporary. The German submarines, as is well known, did a vast amount of damage during hostilities, but they ultimately failed for the reason that the Allies had the mastery of the surface of the sea. A complete navy should, therefore, comprise ships with high freeboard; further, a notable inferiority in such ships cannot be compensated for by a large number of submarines. On the other hand, the fact should not be lost sight of, said one contributor, that about 50 submarines can be built for the price of one single battleship; having two battleships, the French Navy would be considered a weak navy, whereas if France owned, for a cost equal to that of two battleships, say, 100 submarines and 1,000 aeroplanes, such an armament would constitute a force to be reckoned with.

Following upon the experience of the late war, a doubt prevails with many experts as to the advisability of building new battleships; and this state of doubt is likely to continue for many years to come, for there is little probability of such another occasion arising from which it will be possible to gain further and more complete experience on this vexed question. Be that as it may, the present cost of materials coupled with that of labour preclude for the present any extensive construction of battleships, and it is particularly at this point that the financial considerations alluded to in the foregoing step in. In this connection, we venture to believe that many naval experts in the United States and Japan are viewing the new battleship programme of those two nations with a certain amount of concern, in the belief that the construction of these heavy units may not, after all, be the right thing, considering the growing potentialities of other arms.

Notwithstanding the prevailing doubt as to battleships, the French officers advocate dealing actively and as adequately as can be with naval work, a work which, of a necessity, now also includes aerial navigation; aircraft and submarines, among different other units, should be put in hand immediately. The submarines should be of strong construction, and of undoubted endurance. French engineers, it is alleged, have not, for the last ten years, followed the right course with reference to this class of boat; they have built engines which combined too high a power with too great a lightness, and there is no real need to make such drastic sacrifices to speed as has been the custom in the past.

One writer raised the question of the personnel from the purely French organisation point of view, a matter which is quite out of the scope of any criticism from the outside. But this we may add; whatever extensions and additions in point of class and number France makes to her naval and air forces, these will always be viewed by us with the greatest satisfaction, and whatever be the composition of her forces, her personnel in itself will make an alliance with her a desirable one.

Whilst writing the above, there has come under our notice a resolution recently passed at the International Congress of Metal Workers, Lucerne, having for its object the refusal of all metal workers to manufacture arms, munitions and war material of all kinds. We do not know whether German delegates were present at this Congress, nor whether they signed the resolution. But quite apart from this, such a resolution is completely worthless, for the arms, munitions and war material of the future are in many cases only too likely to take the shape of commercial articles in every-day use, as a result of the Machiavelism of which the late war afforded so many proofs.

CARBON MONOXIDE AND THE GAS SUPPLY.

The Gas Regulation Act of August, 1920, radically changed the rules under which coal gas was being supplied to the public. Instead of the candle-power, the calorific value, expressed in "therms," of 100,000 British thermal units, was adopted as the basis for the sale of gas. The Act enabled gas under-

takings to push the development of the gas industry in the direction of recent advance, *i.e.*, for the utilisation of the gas for heating and power purposes rather than as a direct illuminating agent. During the war the gas companies had had to adapt themselves to special requirements and restrictions, and, in their turn, they had sent more and more water-gas and carbon monoxide into the mains.

The Bill, as presented to Parliament in May, 1920, did not tie the gas undertakings down to any fixed calorific power, subject to agreements. As a consequence, the complaints became louder that the calorific power fluctuated, that the "inerts" in the gas, *i.e.*, the incombustible ballast of nitrogen and carbon dioxide, increased in a way embarrassing for furnace regulation, and that the percentage of carbon monoxide in the supply gas rose to dangerous figures. The Bill had required that the gas should not contain any trace of sulphuretted hydrogen, that it should not be at a pressure of less than 2 in. of water gauge in any main or service pipe of 2-in. diameter or upwards, and that it should not contain more than 20 per cent. of incombustible constituents. When the Act passed in August of last year, the main regulations were left as originally proposed, but as regards the inerts and the carbon monoxide, it was decided that the Board of Trade should inquire into the question whether any limitations of the permissible proportions were necessary or desirable. Conforming to the Act, the Board of Trade, on January 3 last, appointed a Committee to "inquire into the question whether it is necessary to prescribe any limitation of the proportions of carbon monoxide which may be supplied in gas used for domestic purposes, and to report thereon." A similar Committee on "Inerts in Gas" was also appointed. The Report of the "Carbon Monoxide Committee" was published a few days ago. We propose to confine our remarks for the present to this Report.

The Committee consisted of Sir William Pearce, M.P., chairman; Dr. Thomas Carnwath, M.B.; Mr. William Doig Gibb, M.Inst.C.E., and Dr. Thomas Gray, D.Sc.; Mr. H. L. Spencer, of the Board of Trade, acted as secretary. The Committee met in February and March last, on five days, both in the mornings and afternoons, and examined 13 witnesses, medical men, gas engineers, chemists and financial experts from the metropolis and the country, and factory inspectors. Most of these witnesses presented instructive reports, and all were submitted to a searching examination.

No question will be raised as to the representative character of these witnesses, but the domestic user was not especially represented. We do not suggest that he might have been consulted, but the terms of reference seem open to question. Parliament—not the Board of Trade—had limited the inquiry to gas used for domestic purposes, and the Committee naturally wished to conform to this rule, so far as that could be done. But it is manifestly impossible in our days to separate the supply of domestic gas and of industrial gas. None of the witnesses were willing to face the expense and the incessant interference with traffic, caused by broken-up roads, which two general systems of mains would involve. What was possible when gas was essentially an illuminant can no longer be advocated in view of the present multiple uses of gas.

The problem before the Carbon Monoxide (CO) Committee had occupied the attention of the Water-Gas Committee of 1898. It had then been proposed that power should be conferred upon a central department to limit the proportion of CO in the public gas supply at night to 12 per cent., but no legislative action had been taken. At that time nearly all the gas used was burnt in flat flames, and its value depended upon the direct illuminating power. The 37 works which supplied water-gas in 1898 only made up 5½ per cent. of the total gas manufactured. By 1919, the amount of water-gas supplied to the public was 15½ per cent. of the total, and it had fully been recognised that the practice of mixing straight coal gas with water-gas, enriched by carburation with oil, had substantial economic advantages. Straight coal gas, made by the gasification of coal in retorts, may contain up to 10 per cent (on average, 7 per cent.) of CO, and carries up to 25 per cent. of the total heat value of the coal; most of the heat energy of the coal is left in the coke.

Gaseous fuel being more efficient, more convenient and cleaner in application than solid fuel, the modern tendency is in favour of gasified fuel, and on a manufacturing scale carbon can only be gasified as carbon monoxide. According to Mr. J. W. Cobb, Livesey Professor of Coal Gas and Fuel Industries in the University of Leeds, one of the experts examined, the thermal efficiency of gas production for straight coal gas ranges from 45 per cent. up to 55 per cent., whilst fixed carbon can be gasified by steam in the blue water process with an efficiency of 70 per cent. Other gas processes are being worked out and improved. From the safety standpoint, the objection to these processes is that blue water gas (not carburetted) contains 42 per cent. of CO, and that even the carburetted gas may contain 30 per cent. of CO. Can such a gas be tolerated in our mains, gas meters, and burners?

The evidence given before the Committee for and against a limitation of the CO, ran almost on party lines. That is to say, the gas and fuel experts protested against any restriction as it would cripple the gas industry and with that the development of industry in general, and insisted upon the advantages, including the hygienic superiority, of gaseous fuel, whilst the medical experts—with one exception—and the factory inspectors as decidedly pleaded for a restriction in the interests of safety. Much of the medical evidence now offered practically goes back to the investigations which the departmental Commission of 1898 has instigated. Dr. J. S. Haldane then experimented chiefly in closed rooms, devoid of ventilation, especially in order to ascertain the percentages that would be fatal to people sleeping in rooms where gas escaped or had been blown out. In his examination, he admitted that he would like to supplement his experiments, particulary also as to the cumulative effect of small proportions of CO. While not underrating the dangers, he thought that, considering the improvements in appliances, 20 per cent. of CO would be a reasonable maximum.; that would allow 33 per cent. of blue water gas, or 50 per cent. of carburetted water gas to be mixed with coal gas. Dr. A. G. R. Foulerton, representing the Society of Medical Officers of Health, ascribed a certain anæmia to CO; pressed as to practical evidence, he replied that it would be difficult to give actual proof, but that was mostly so in matters medical. Both the factory inspectors to the Home Office, Mr. Stevenson Taylor (senior engineering inspector), and Dr. T. M. Legge (senior medical inspector) were emphatically in favour of restriction, stating that carbon monoxide formed the bulk of gas accidents in factories. The Memorandum of the Factory Department of the Home Office on Carbon Monoxide Poisoning, to which we referred on page 259 of our issue of August 12, leaves no doubt as to the serious view taken by these officials of the problems. On behalf of the Fuel Economy Committee of the British Association Mr. Robert Mond pleaded for a restriction of the CO to 20 per cent.; he also expressed the opinion that the high advantages which previous witnesses had claimed for gas very rich in CO could, by scientific methods, be secured also at lower CO percentages.

The statistics given by Dr. Stevenson, of the Registrar-General's department, on Mortality from Gas Poisoning (including suicides and murders, by the way), indicated an increase in the number of fatal cases since the introduction of a more highly-poisonous gas. The death rate ascribed to accidental coal-gas poisoning for the seven years 1913 to 1919 was, for England and Wales, 1·9 per million of population, 3·1 for London and 3·0 for the large towns. In 1919, the rate was 5·4 for certain towns supplied with water gas, and 2·1 for other areas not supplied with water gas; in two large adjacent towns, belonging to the two classes just mentioned, the Committee itself ascertained that the rates were 3·5 and 0; this is really the most distinct case in point. Dr. Leonard Hill, of the Medical Research Council, differed from his colleagues. He confirmed Dr. Haldane as to 0·02 per cent. of CO being sufficient to cause headache and nausea, but he did not at all support any restriction. He knew of no definite evidence connecting the number of accidents with the percentage of CO, but thought that valuable information might be obtained from America. If there were chronic CO poisoning, smokers should suffer from it, and he would not hamper the gas industry, which helped to secure a cleaner atmosphere, any more than he would restrict the automobile industry, though motor accidents were undoubtedly increasing.

The Committee's Report draws attention only to the evidence of Dr. Haldane and Dr. Stevenson—they are, in fact, the only witnesses named in the Report—but the Committee studied also the statistics for the years 1914 to 1919, collected by the Light Commissioners of Masschusetts, and finding these statistics peculiar—undertakings supplying 100 per cent. water gas had 26·4 deaths per million; companies supplying a water gas of 50 per cent. and upward, 59·3 deaths; undertakings with a water gas of less than 50 per cent., 29·3 deaths—they applied to Dr. H. S. Cummings, Director-General of the United States Public Health Service. The reply received states that the CO percentage is not restricted in the United States, because that would economically be disadvantageous, that 20 per cent. or 30 per cent. of CO would make little difference, and that incomplete combustion in badly-adjusted appliances was more dangerous than leakage from defective fixtures; recent cases were, moreover, due probably to the toxic action of the illuminants in the gas rather than to CO. It was perhaps as well that Dr. Cumming was not cross-examined as to these latter statements.

The representatives of the gas industry, Mr. Thomas Goulden, Dr. Charles Carpenter, Mr. F. W. Goodenough and other eminent gas engineers and chemists, as well as Professor Cobb and Sir Dugald Clerk, deprecated any restriction. Though disclaiming any present intention to go above 33⅓ of carburetted water gas, in London at any rate, some experts submitted that 100 per cent. blue gas would not mean undue risk—provided the gas were given a distinct smell. In actual practice, the smell is simply derived from the coal gas which is mixed with the water gas, 5 per cent. of coal gas being considered sufficient for this purpose. No special evidence was taken on that point, which seems to us to be very debatable. A good many people practically possess no sense of smell, and that stale smells fail to attract attention was recently recognised by the United States Bureau of Mines, when they investigated the reliability of warnings in mines given by the aid of stenches. On the other hand, the gas technologists pointed, not without reason, to the better education of the people who do not neglect gas escapes, and to the improved type of burners and meters in use, as well as to the inspection of gas installations which the companies have initiated, and for which members of their staffs are especially trained. The improvements of the fittings in small old houses may still leave a great deal to be desired, and the supervision may be somewhat sporadic. The slot-meters, which are popular, necessitate regular visits by the company's servants, however, and the company may alter and fix fittings, and advance is certainly being made in the right direction.

As regards statistics, moreover, the gas industrials affirmed definitely that accidents had not increased with the rising percentage of CO in the gas they manufactured, and that their own men should surely suffer first if the more poisonous gas were more dangerous. It may be, and greater caution, on the part of both the administration and the men, may account for the fact, which is certainly significant. One wonders a little all the same, and the questions of what constitutes an accident and of chronic cumulative effects and general injury to health here come up again. The Committee received no definite evidence on the latter point; none may be available. That the carbon monoxide in some way interferes with the capacity of the hæmoglobin in the red blood corpuscles to act as oxygen carriers, is probably common belief; but the mechanism of carbon monoxide poisoning, and of all acute poisoning by gases—apart from suffocation—is still, we think, controversial. The gas companies did not fail either to dwell upon the advantage of a clean fuel, producing neither dust nor soot, smoke and fog, and saving much domestic labour.

As regards the advantages of a high CO gas to themselves, the gas makers are on pretty safe ground. The present cost of installing water-gas plant, they stated, was only a third of that of providing straight coal gas plant of equal capacity, while much less labour was required in the manufacture of the gas. Moreover, the surplus coke, which was difficult to sell, was put to an economic use, and the flexibility of water-gas plant was strongly in its favour. In cases of emergency, the water-gas plant could be started in a few hours, while it would require days with coal gas. So much gas is now utilised for heating, moreover, that a sudden drop in the thermometer causes a sudden rise in the demand for gas which coal-gas plant could only meet by large reserve plants and large storage accommodation. Again, the gasification of coal can be combined with a recovery of the by-products; the conversion of carbon into its monoxide is thermally efficient, and the product is not by any means unwelcome as fuel for internal-combustion engines, These points hardly require emphasis in our columns. National economy would be promoted by an extended use of gaseous fuel.

Convinced of these economic advantages and greatly impressed by the necessity of allowing the development of the gas industry to proceed without any check on its natural progress, the Committee report "that it is not necessary or desirable to prescribe any limitations of the proportions of carbon monoxide which may be supplied in gas used for domestic purposes." They do not ignore the increased risk, but they do not consider that the increased risk will be found serious. They suggest that the danger of an increased death rate is in any case of small dimensions, and that the certain improvement in the public health by the reduction of smoke and fog arising from increased use of gas as fuel should be set against the risk.

They, however, qualify their recommendations by two reservations. In the first place, they strongly urge, in accordance with all the witnesses, that the distinctive odour of coal gas gives a warning of leakage which is absolutely necessary, and they would make it an offence to supply any gas for domestic purposes which does not possess the distinctive pungent smell of coal gas. We should mention that the distinction between gas for domestic purposes and for industrial purposes is not discussed in the Report.

The second of the two reservations to which we have referred above consists of a suggestion that the "department concerned should carefully watch the situation so that, if the freedom from limitation which we recommend is accompanied by unexpectedly unfavourable results, the attention of Parliament may, if necessary, be again directed to the matter." In making this second reservation, the Committee may have borne in mind the possibility, pointed out in the evidence, of some wholesale CO poisoning being caused by the bursting of a gas main. Such an accident, however, would probably cause little more than a temporary sensation. Our age is reckless, and having to put up with a great deal in some respects, resents interference in other matters.

IMPERIAL AIR COMMUNICATIONS.

After careful consideration of the report of the Imperial Air Communications Committee, at the Conference of Prime Ministers and Representatives of the United Kingdom, the Dominions, and India, the latter body has recommended that the proposals made in the report should be submitted for the consideration of the Governments and Parliaments of the different parts of the Empire. It is also suggested that, pending this consideration, such existing material as may be useful for the development of Imperial Air Communications should be retained.

The Committee submitted two estimates to the Conference covering periods of one year and two years, respectively, but pointed out that neither scheme was complete in itself. If the former scheme were inaugurated by September 1 next, it would be possible to start a monthly service to Egypt by March of next year, and, by the end of the period, to make demonstration flights in the direction of India and South Africa; landing in those countries would not, however, be possible, unless masts had been previously provided. The total cost of this scheme, which would cover the necessary research and training flights at home, was estimated at 540,000*l.*, this sum including capital expenditure of 177,000*l.*, running expenditure of 253,000*l.*, and an allowance of 110,000*l.* for contingencies. The airships R36, R37 and L71 would be used on this service, and R33 would be employed as a reserve for training purposes.

With the alternative scheme, covering a two-year period of inauguration, a monthly service to Egypt would commence in March next, as in the scheme outlined above, but this monthly service would be extended to India in the following September, while demonstration flights towards South Africa would be carried out during the last two or three months of the period. The estimated total cost of this scheme is 1,339,000*l.*, allowing 493,000*l.* for capital expenditure, 626,000*l.* for running expenses, and 220,000*l.* for contingencies. This expenditure provides for the erection in Egypt of a complete base with shed, as distinct from a station with mooring mast allowed for in the one-year proposal, and the Committee point out that whereas the costs of the two schemes are in the ratio 1 : 2½, the useful work accomplished in the two cases bears the ratio 1 : 5.

As previously mentioned, the above proposals do not form complete schemes for Imperial communications by airship, further development being dependent on the construction of new airships specially designed for the particular service. The Committee consider that 10 to 12 airships, each of 4,000,000 cub. ft. capacity, would suffice to maintain a fortnightly service from England to Egypt, India, South Africa, and Australia; the first of these ships, it is estimated, would cost about 300,000*l.* Development would also depend on the provision of masts and bases. Permanent bases, for example, would be required in South Africa and Australia before the route could be extended to the latter Dominion. Such bases would cost about 400,000*l.* each, and as additional shed accommodation would be required in England, a sum of about 500,000*l.* would have to be allowed for this. The development of the service for a further period of three years would, therefore, involve a capital expenditure of 4,545,000*l.*, a sum of 901,000*l.* for maintenance of ground organisation, and an allowance of 1,500,000*l.* for contingencies, to which must be added the cost of upkeep and operation of the airships themselves. This latter item would increase from 160,000*l.* per annum at the end of the two-year period to 1,094,000*l.* per annum at the time when regular fortnightly services were being operated to India, South Africa and Australia. The above-mentioned capital expenditure includes the construction of 12 new airships.

To enable the possible revenue from the services to be estimated, the Committee give some figures as to the carrying capacity of the airships to be employed. R36 and R37 could carry 30 passengers and 2 tons of freight between England and Egypt, with an intermediate stop at Marseilles for refuelling, while, under the same conditions, the carrying capacity of L71 would be 40 passengers and 7 tons of freight. The latter ship, without stopping at Marseilles, could carry 35 passengers and 2 tons of freight from England to Egypt, or from Egypt to Karachi, and the proposed new 4,000,000 cub. ft. airships could carry 50 passengers and 13 tons of freight for the same distances.

Although the estimates above referred to assume the adoption of a scheme of development by direct Government action, the Committee express the opinion that the best results would be obtained by private enterprise conducting a service for profit in a similar manner to the Mercantile Marine. They also analyse three proposals received from Mr. A. H. Ashbolt, Mr. M. M. Greenhill and Lieut.-Commander Ballantyne. Space will not permit us to give a detailed explanation of these schemes, which were submitted in response to the Government offer referred to on page 688 of our last volume, but we may mention that in the first-mentioned proposal, the Governments concerned are invited to take part in subscribing for share capital and also to grant a subsidy for 10 years. In the second scheme all the capital is to be raised by public or private subscription, but a Government subsidy is required during the development period, together with guarantees of mail contracts, while the third scheme involves a guarantee of interest as well as subsidies from the Governments concerned. It thus appears that no scheme independent of State aid has been formulated, and this, although regrettable, is probably inevitable in existing circumstances. The matter of high-speed transport, however, is of the utmost importance to the Empire, both politically and commercially, so that it is to be hoped that careful consideration of the various proposals by the Governments concerned will enable reasonable solutions to the financial problems to be found. Such technical difficulties as exist, we are confident can be met and overcome without unduly straining the designing, manufacturing and operating resources of this country.

NOTES.

The Loss of the R.38.

As we go to press the news comes to hand of a disaster which has overtaken the British-built airship R.38, that was to have been purchased by the United States Navy Department and re-named Z.R.2. The vessel, which was fully described on page 723 of our last volume, left Howden station on Tuesday morning, the 23rd inst., to carry out a series of trial flights, and was to have returned to Pulham station the same evening. Low-lying clouds, however, prevented the landing at Pulham, and it was therefore decided to cruise over the sea throughout the night and continue the trials on the following day. This was done, and everything seems to have proceeded satisfactorily until about 5.30 p.m. on Wednesday, when the airship, flying in the neighbourhood of Hull, apparently broke in two and fell in flames into the Humber. The most distressing feature of the disaster is, of course, the appalling loss of life which has occurred, only 5 of the 49 persons on board having escaped with their lives. Of the British officers on board those best known to our readers will probably be Air-Commodore E. M. Maitland, Flight-Lieutenant J. E. M. Pritchard, Mr. J. R. Pannell and Mr. Duffield (both of the National Physical Laboratory), and Mr. C. I. R. Campbell, the superintendent of the Royal Airship Factory at Cardington, who was the designer of the airship. All these appear to have perished, and their loss will be mourned by a wide circle of friends in the airship service. Mr. H. Bateman, of the National Physical Laboratory, was among the few saved. It is too early at present to comment on the cause of the accident, but from the published statements of eye-witnesses it appears to have been due to some structural defect, possibly developed during the full-speed trials which were either in progress at the time or had been carried out just prior to the accident. On a previous flight, carried out on July 17 last, it seems that some of the girders had been strained, although not sufficiently to curtail the flight. They were afterwards strengthened at Howden, the work being completed by the 30th ult., and the trial flight, which ended so disastrously, was the first carried out since that time. It is to be hoped that a careful examination of the wreckage will disclose the cause of the accident, since the development of airship transport will suffer a severe check until the non-recurrence of a similar disaster can be guaranteed with all human certainty.

The Properties of Steam.

The American Society of Mechanical Engineers is being urged to finance a new enquiry into the properties of steam at high pressures and temperatures. The work is expected to extend over three years and to cost 35,000 dols. per year. Part of the work, it is proposed, should be carried out by the United States Bureau of Standards. If the American Society of Mechanical Engineers does take up the matter it is to be hoped that it will bear in mind that in experiments of such difficulty as here contemplated precision is less a matter of lavish expenditure than of native genius on the part of the observer, and much will depend upon the choice of investigators. In ingenuity and precision the best experimenters in the United States stand second to none, but men with such

qualities are everywhere rare, and like other countries the United States has its mediocrities, of whom the best that can be said is that they are plodding and persevering. Such men often get "consistent" results which are consistently wrong, whilst the man of genius by suitably devising his experimental scheme will obtain really reliable figures at one-tenth the expenditure. It may be noted moreover that a much more pressing and important investigation would be one into the laws of expansion of super-saturated steam, since there is every reason for concluding that wet steam never does expand in a condition of thermal equilibrium, whether this expansion be effected in a turbine or in a reciprocator. The effect of this on the apparent efficiency ratio of a turbine is many times as great as those that may be due to possible small residual errors in the best steam tables.

British Shipping and Shipbuilding.

Although the trade of the United Kingdom as evidenced by shipping statistics for 1919, showed a material improvement in comparison with the previous year, it was still well below that of 1914. From the annual statement of the navigation and shipping of the United Kingdom for 1919, it appears that 201,403 vessels, with a total net tonnage of 96,819,104, arrived with cargoes and in ballast at United Kingdom ports from foreign countries, British Possessions and coastwise, whereas the corresponding figures for 1914 were 326,900 vessels and 154,098,175 net tons. The lowest figures for the war period were reached in 1918, when the vessels arriving numbered only 160,617, and had a total tonnage of 63,784,906. The 1919 tonnage was, therefore, over 50 per cent. more than the latter figure, and about 37 per cent. less than that for 1914. The total number and tonnage of vessels owned in the United Kingdom, and registered under Part I. of the Merchant Shipping Act, 1894, also showed an increase in 1919, for the first time since 1915. The increase in the British merchant fleet during the year under consideration was 146 vessels and 825,205 gross tons, the total figures for 1918 being 18,190 vessels and 16,364,403 tons, while those for 1919 were 18,346 vessels and 17,802,511 tons. The latter figures are still much lower than those for 1914, when the British merchant fleet included 21,065 vessels with an aggregate gross tonnage of 20,009,820, the difference in tonnage amounting to 11 per cent. An indication of the efforts made to make up the deficiency in tonnage is afforded by the fact that the total net tonnage of vessels built in the United Kingdom for British owners, amounted to 936,532 (757 ships) in 1919, as compared with 838,608 tons (1,010 ships) in 1914. For the other war years, the number and net tonnage of vessels built were 522 ships and 374,446 tons in 1915, 479 ships and 386,315 tons in 1916, 397 ships and 752,120 tons in 1917, and 320 ships and 820,884 tons in 1918. It is interesting to notice that the average size of vessels built at first diminished during the war period, falling from 830 tons in 1914 to 717 tons in 1915, and afterwards increased again to 807 tons in 1916, 1,895 tons in 1917, and 2,565 tons in 1918. The increase, however, was not maintained during 1919, since in that year the average net tonnage comes out at 1,238, a figure which, although considerably higher than that for 1914, is less than half that for 1918, the last year of the war.

Oil Fuel for Steam Boilers.

One result of the recent coal stoppage was to give a number of engineers some experience in the application of oil fuel to steam boilers. The applications were in general a success from the point of view of their main intention, which was to enable work to be carried on, but in many cases there was much to be desired from the point of view of economy. In a pamphlet issued by The Manchester Steam Users' Association, a case is quoted in which a cross-tube vertical boiler used a weight of first-class fuel oil equal to that of the very poor coal previously used for the same duty. This is, no doubt, an extreme example, but in very many instances oil fuel hardly fulfilled the hopes of its users. In view, however, of the haste with which the majority of the installations were made and the fact that many were from the first looked upon as of only of a temporary nature, this result is not surprising. The experience gained will in many cases have been of considerable value, and the pamphlet to which we have already referred, in bringing some of these experiences together and making them generally available, is much to be commended. The pamphlet has been prepared by Mr. C. E. Stromeyer, the Chief Engineer of the Association, and in addition to an analysis in general terms of the combustion processes taking place in the burning of oil, which are marked by Mr. Stromeyer's usual acumen, it contains a report by Mr. E. G. Ritchie, one of Mr. Stromeyer's assistants, on actual installations inspected. The report reviews the pressure jet, and steam and air-jet systems, and very clearly attributes the best economy to the former. This type of burner, however, requiring a pumping set and special furnace fronts, does not lend itself to such cheap and rapid installation as steam or air-jet systems, particularly the steam jet. In many of the simple and more or less temporary installations it was found that the oil was sprayed rather than atomised, with the result that globules of oil of appreciable size were thrown off. These globules were too large to be burned at once, and as the temperature of the flame fell rapidly beyond the region of maximum burning, there was no chance for complete combustion of the globules, and much of the oil was wasted. Mr. Stromeyer points out that a perforated brick screen would assist in such cases, but it must be made of the best firebrick if it is not to melt. The brick combustion chambers of water-tube boilers offer great advantages in this connection, and in one case of a Stirling boiler, the waste gas temperature dropped 600 deg. F. with coal to 450 deg. F. with oil. This was due to more perfect combustion, and as it was accompanied by a reduced air supply, there was a double gain. The flame temperature was so high, however, that after four days' working 14 inches of firebrick had been destroyed. In general, the steam jets were more successful with the lighter fuel oils, but pressure systems dealt equally well with either light, or heavy oil. Weight is laid in the pamphlet on the necessity for maintaining the special precautions pertaining to fuel oil burning for at least a week after a return to coal firing.

LITERATURE.

Thermionic Tubes in Radio-Telegraphy and Telephony. By John Scott-Taggart, Associate Member of the American Institute of Electrical Engineers. London: The Wireless Press, Limited. [Price 25*s*.]

It has become a commonplace for a lecturer on wireless telegraphy to excite the admiration, or the curiosity, of his audience, by capturing radio signals despatched from a distant station and translating them into familiar symbols. Such experiments are very effective and generally give more satisfaction than the explanation of the mechanism by which such results are achieved, for the previous spadework necessary for the adequate apprehension of complicated apparatus is usually wanting. It is this less spectacular but more onerous task of full and lucid explanation, that Mr. Scott-Taggart attacks with equal knowledge and address, and his book should be welcome to the technical student. The inquiry is limited to the examination of the theory and use of the thermionic valve in its various applications, and this limitation is not without many advantages. The author is not required to refer to the atomic structure of electricity, to sketch imperfectly the conclusions of Sir J. J. Thomson on the connection between the electron and negative electricity, or to enter upon much irrelevant matter, of profound interest in certain directions, but of little direct assistance in demonstrating the practical use of the Fleming valve, or tube, as the author prefers to call the developed mechanism, which has revolutionised and widened the possibilities of wireless methods of communication.

Regarded in its essentials, or original form, as illustrated and explained in the earlier chapters, the valve is seen to be of singularly simple construction giving few indications of its many after modifications and applications. Its history, though limited to only a few years, illustrates the principle that the growth of mechanical science is effected by a process of accretion, rarely by revolution. Edison had noted twenty years earlier than the date of Fleming's master patent, that a current would flow between the positive terminal of a lamp filament and a metal plate sealed in the bulb. Fleming, in search of a more reliable detector than coherers or crystals offered, availed himself of the neglected fact to contrive an apparatus which permitted electricity to flow from a heated filament to a plate enclosed in a vacuum bulb, necessitating that the plate be at a higher potential than the filament. In this way was produced the means of rectifying alternate current. Then de Forest introduced a valuable modification, which gave birth to the three-electrode vacuum tube, on whose improvements the skill and ingenuity of rival electricians have found ample scope. We believe that this step is rightly credited to de Forest, but it is not so clear from his early patents that he designed the "grid," to use the term as applied to the many forms which the third electrode subsequently assumed, with the view of controlling the flow of current from filament to plate, which is its proper function. The author has experienced great difficulty in assigning due credit to the proper authority for different developments, and we have no intention of embarking on this invidious course.

The author's main object being to follow the development of the thermionic valve and to trace the circuits best adapted for securing particular effects, he escapes much of the theory founded on the passage of electricity through gases, but is inevitably brought up against the so-called "characteristic curve," and discusses very amply the advantages its varying forms offer to the practical man, both in suggesting the suitable arrangement of his apparatus and in furnishing explanation of observed effects. The author's treatment is lucid and informing and the student should have no difficulty in apprehending the usefulness of this curve, that theory and experiment alike have placed in his hands. By its aid, the process of rectification, for example, may be seen in a truer perspective, the inefficiency or limitations of the two-electrode valve under certain conditions can be more easily grasped, while later, the examination of the grid potential reveals possibilities in the "triode" that assume a very practical shape.

The discussion of the properties of the anode current and of the grid potential forms a very good introduction to the description of the vacuum tube as a detector and as an amplifier, treated here in two separate chapters that may be commended to the attention of the technical student, the class for whom we conceive the author is writing. In the earlier, the features of "hard" and "soft" vacuum tubes are contrasted, and the effect of grid leakage in providing a convenient means of giving the grid a suitable normal operating potential is considered. In the latter is seen the use of transformers in obtaining as great a variation of grid potential as possible, and the use of resistances as an alternative is adequately explained, the advantages and disadvantages of the two methods being commented upon.

A chapter on retroactive amplification follows, in which Mr. Scott-Taggart further illustrates the problem of increasing incoming oscillations by means of the vacuum tube. The essential principle consists in making the amplified oscillations in the anode circuit retroact on the grid circuit and reinforce the original E.M.F. on the grid. The author recognises four methods of obtaining retroaction, described as indirect and direct magnetic coupling, and electrostatic and conductive coupling, but it may be doubted if these are all independent, or serve any other purpose than a convenient classification of the circuits. The original arrangements, designed by Meissner, Armstrong, Franklin, Lee, de Forest and others to increase the duration of wave trains of damped waves suggest almost unlimited possibilities, were it not that a limit is fixed to this form of amplification by the possible interference of two successive wave trains. When the circuits involved begin to oscillate on their own accord, new phenomena are introduced, which the author considers under the heading of multistage retroactive receiving

currents, having disposed of the problem of the detection of incoming amplified oscillations and the use of vacuum tubes in cascade as amplifiers of high —or low—frequency oscillations.

The chapter on continuous waves, considering the growing importance of this development and the interest attaching to heterodyne reception, might, perhaps, have been extended with advantage. But the description of the selected examples is exact and stimulating. The ingenuity displayed in the introduction of local oscillations to create the "beat," the invaluable quality of selectivity, especially pronounced in the case of short waves, and the possibility of maintaining a note, of pitch agreeable to the operator, have made this method of reception popular and widespread. It is true that some self-heterodyne circuits will radiate while receiving, but generally the oscillations are weak and have little effect. When, however, stations are "searching," waves of very varying lengths may be transmitted and much mutual interference result. The author recommends that regulations should be enforced that would forbid the use of circuits which radiate while receiving. Since the number of stations, and consequently the inconvenience, will continually increase, the suggestion is deserving of consideration. There seems to be some difference of opinion as to the degree of amplification attainable by the usual forms of apparatus, some insisting that the maximum true amplification is four, and that this is obtained when the local current is equal in amplitude to the signalling current, and that any further increase in response, which may be obtained by an increase in the local current, is due to an improvement in the efficiency of the receiving apparatus. This view is opposed by others, who hold that the amplification obtainable is unlimited, and in presence of these conflicting statements the author wisely abstains from expressing an opinion, but refers readers to the original publications.

It is evident that since an oscillating vacuum tube is employed to generate local oscillations, an increase in the output of these oscillations will furnish a useful transmitter of continuous waves. This is not the route, however, by which the oscillating properties of the three-electrode valve became recognised and have been investigated. The discovery is more probably traceable to the action of the "buzzing" telephone. A bell telephone receiver in circuit with a battery and carbon microphone transmitter emits a continuous musical note when brought near to the transmitter, on account of the feeble vibrations set up in the microphone diaphragm by noises in the room continually varying the current through the telephone receiver. Several authorities claim the merit of the original discovery in a practical form, and the author seems inclined to award the distinction to de Forest, who, from experiments on his audion, probably knew of the action, without appreciating its value. General opinion has been inclined to award to Meissner the discovery, that in certain circumstances the three-electrode thermionic tube could act as a generator of oscillations. Apparently he was the first to employ the phenomenon of retroaction to produce continuous waves for wireless transmission. Many of the early circuits employed are reproduced, some taken from the original patent descriptions. It should be said that the circuits here, and throughout the book, and particularly in the last section on wireless telephony, are a very agreeable feature. The presentation of the practical working arrangements constitutes a very valuable part of the treatise. The recognised system of symbols standardised by the radio-engineer permits these diagrams to be easily followed, and greatly increases their educational value. Mr. Scott-Taggart has made a notable addition to the literature of the subject. The time will come when selection will have to be more stringently exercised, but at present the history is too interesting to permit curtailment.

Technical Methods of Analysis. By Roger Castle Griffin. First Edition. New York and London: McGraw-Hill Book Company. [Price 33s. net.]

To the past generation the professional chemist was either a pharmaceutist or an analyst. The scientific chemist was hardly recognised outside the universities, and the manufacturing chemist employed analytical chemists in his works, but was not himself regarded as a chemist and did not lay claim to that designation. At present pharmacy is a profession of its own; technical chemists indeed consider themselves alone entitled to being styled chemists. The head of a manufacturing firm may himself be a distinguished chemist, and the analyst, if not specialising in metallurgy or in oil, *e.g.*, prefers to be known as an analytical and consulting chemist, lest people think that he has to restrict himself to the routine analysis of the old days.

Much of that routine work is so manifold, complex and difficult that the analysts have had to adopt conventional methods. The public expects more perhaps of the analytical chemist than of any other professional man, except the physician, whose successes and failures the public is generally not in a position to judge. We must not belittle the chemist because he may easily demonstrate the presence of arsenic in some mixture or liquid, but may be quite unable to account for the poisonous character of some food. All that he can say is that corrosive agents, metals and alkaloids seem to be absent, and it will require competent and arduous work to state that much. An analytical chemist is supposed to be able to test and to analyse salts, metals, fuels, paints, oils, fats and soaps, wood, paper, textiles and bleach, foodstuffs, &c., and to perform various other analyses, both organic and inorganic, dealing with boiler scale, leather, tar, and concrete. We take these subjects from the sectional headings of Mr. Roger Castle Griffin's "Technical Methods of Analysis." Mr. Griffin adds to his title "as employed in the Laboratories of Arthur D. Little, Inc., Cambridge, Mass"; he is Director of the Analytical Department of this firm.

Analytical chemistry is far too wide a field for one man and one book. One therefore welcomes the restrictions, which Mr. Griffin imposes upon himself, though he does not really confine himself to methods used in his own laboratory, of course. He excludes theoretical deductions of the methods of analysis and certain divisions, such as the rare metals, ores, minerals, rocks, glasses, as well as drugs, alkaloids, &c. That will be acquiesced in. That gas analysis is cut out, may be regretted; but quantitative gas determinations call for a rather special equipment and training. Yet one would expect some reference to the gases occluded by metals. The few words on indicators do not make mention of the widely used indicators turmeric, curcumin, congo and lacmoid, nor even of our old friend litmus, and the notes are of no service without directions as to the applications and limitations of the indicators. Prominent among the methods, with which the author has no direct connection, are those of the Association of Official Agricultural Chemists and of the United States Bureau at Washington. No objection will be raised to this preference, and in these and other cases we have references to pamphlets and other literature, not infrequently without dates, unfortunately. The importance of the date is too much disregarded by authors; the date will often tell the reader at once, whether or not a certain modification of a method can be discussed in the paper quoted. In the bibliography list at the end of the book the dates of publications are given, and that is a praiseworthy feature. It should also be mentioned that the tables of constants give the figures and their common logarithms, and that the volume is supplied with a good index. On the whole the 666 pages contain as much information as can be expected from a general text book which is not compiled for the benefit of the specialist and which, we might add, is not written for the engineering chemist.

Detail Design of Marine Screw Propellers. By Douglas H. Jackson, M.I.Mar.E. London: Sir Isaac Pitman and Sons, Limited, 1, Amen Corner, E.C.4. [Price 6s. net.]

The development of technical education for apprentices which has been a marked feature of post-war activities, as well as the increasing numbers of students attending technical evening classes, is bound to create a demand for text books suitable for the use of such students. As a very considerable proportion of these students will in the course of their life-work be called upon to deal with problems of a practical rather than a theoretical nature, there is much wisdom in confining the scope of such text books to the more practical side of the subject, and in particular to the demonstration of the methods of applying the results of scientific investigation to practical problems. This is the more so as for the majority of such students the knowledge of the precise mathematical reasoning upon which results are based is entirely unnecessary even if it were within the limits of their educational equipment.

Among draughtsmen and others there is always a demand for text books dealing with their subject, and here again the ideal book for the majority is that which indicates the practical application of principles to everyday problems rather than the mathematical demonstration of these principles. However deplorable this may be from the point of view of the educationalist it is well that the demand for information of the above nature should be fully met by the provision of text books containing the maximum of practical information with the minimum of mathematical demonstration. Such a book has been produced by Mr. Jackson, and his recognition of the essentials of a practical hand book is evident in his treatment of the subject.

Design is dealt with in Chapter I and Scantlings in Chapter II, and in both cases the student is introduced directly to various formulæ in common use in determining the leading characteristics of a screw or screws to suit given conditions. By the use of numerous examples the application of these formulæ to concrete cases is clearly shown, and no difficulty should be experienced by any student in applying them to the fixing of particulars to suit given conditions. The preparation of working drawings is described and illustrated in a short chapter, and here again the practical aspect of the work in conveying the necessary information to the pattern maker and foundryman is given special prominence. Useful information on the method of building up and making wood patterns for moulding propellers, also on the method of moulding direct in sand by means of the "sweep board" and "pitch plate" is given in Chapter V., while Chapter VI. carries the practical work to the final stage by describing the operations of marking off, checking the pitch, machining, finishing and balancing various types of propeller. The author concludes with a short chapter on repair work as applied to propellers and discusses shortly methods of repairing small fractures by "burning on" and electric welding. The method of obtaining particulars for a new propeller or blade from the original while still in position in the ship, and the methods employed in removing propellers from the tail shaft are described. An appendix giving definitions of the technical terms used in the text, tables of useful numbers, an index, plates giving curves for estimating the values of the factors used in the design formulae, and finished drawings of propellers of various types complete the work.

To those who have occasion to acquire a sound working knowledge of the basic principles of propeller design and also desire to know something of the practical work of making and fitting propellers we can thoroughly recommend this little volume.

BOOKS RECEIVED.

Reflections of a Financier: A Study of Economic and other Problems. By Otto H. Kahn. London: Hodder and Stoughton, Limited. [Price 10s. 6d. net.]

Economics of Bridgework; A Sequel to Bridge Engineering. By J. A. L. Waddell, C.E., B.A.Sc., Ma.E., D.Sc. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 30s. net.]

Fuel Economy Monographs. No. 1. Practical Suggestions for the Economical Working of Boiler Plant. London: Federation of British Industries, Fuel Economy Department, 39, St. James's-street, S.W. 1. [Price 2s. 6d. net.]

Investigation of Warm Air Furnaces and Heating Systems. Bulletin No. 120. *Engineering Experimental Station, University of Illinois.* By A. C. Willard, A. P. Kratz and V. S. Day. Urbana, Ill.: University of Illinois; London: Chapman and Hall. [Price 75 cents.]

Collection and Disposal of Municipal Refuse. By Rudolph Hering, D.Sc., and Samuel A. Greeley. First edition. New York and London: McGraw-Hill Book Company, Inc. [Price 42s. net.]

The Chemical Trade Year Book and Buyers' Guide, 1921. London: Bandon and Morris. [Price 12s. 6d. net.]

THE LATE SIR SAMUEL CLELAND DAVIDSON.

WE regret to have to announce the death, which occurred on the 18th inst., at his residence, Seacourt, Bangor, Co. Down, at the age of 74, of Sir Samuel Cleland Davidson, the chairman and managing director of Messrs. Davidson and Co., Limited, Sirocco Engineering Works, Belfast.

Sir Samuel Davidson was born in 1846 in County Down, and received his education at the Royal Academical Institute, Belfast. Very early in life he evidenced a keen interest in science and engineering. He entered in 1861 the office of Mr. W. Hastings, a civil engineer of Belfast, under whom he acquired a good knowledge of surveying and a rudimentary training in architecture and railway engineering. In 1864, Sir Samuel's father, having purchased a share in a tea estate in India, and in the belief that his son would have good prospects of advancement in life as a tea grower, sent him to India in the autumn of that year. On arriving at the estate, in the tea district of Cachar, about 300 miles north-east of Calcutta, Sir Samuel acted as assistant manager for two years of the estate in which his father was interested, when he became manager. On his father's death in the year 1869, he bought out his co-partner and became sole proprietor. Sir Samuel soon realised the inadequacy of the primitive methods then followed for dealing with tea, and practical experience, combined with his inventive genius, suggested to him the possibility of replacing those primitive methods by mechanical appliances at the plantations themselves. He subsequently gave up tea planting and returned to Ireland, where he founded the Sirocco Engineering Works in the year 1881.

Starting with one small workshop and seven workmen, the works are now extensive, well equipped, and employ about 1,000 hands. They have specialised mainly in the manufacture of the well-known Sirocco fans and in the construction of tea and rubber machinery. As we stated on page 712 of our preceding volume, when dealing with the Rubber Exhibition held last June at the Royal Agricultural Hall, Islington, the Sirocco Engineering Works displayed on that occasion a very complete and most interesting series of working models for the manufacture of rubber, starting from the latex. Apart from the three specialities above referred to, Sir Samuel's inventions cover a wide field in the realm of mechanics, and he was a man of exceptional business ability with highly developed powers of organisation.

He became a member of the Institution of Mechanical Engineers in 1888, and, as recorded by us a few weeks ago (page 15 *ante*), he was made a Knight of the Order of the British Empire on the occasion of the Royal visit to Belfast in June last, when the King opened the first Parliament of Northern Ireland. Sir Samuel's elder son, Captain J. S. Davidson, was killed in the war; a younger son died in boyhood. His wife predeceased him a few years ago, and he is survived by two married daughters.

SAFETY PETROL TANKS FOR AIRCRAFT.—While owing to careful design and inspection there is now little risk of aircraft taking fire in flight, there is still a possibility of the fuel tanks bursting or leaking in the event of a crash or a heavy landing and of the escaping of petrol becoming ignited. In order to obtain for service and commercial aircraft tanks capable of withstanding the rough treatment above referred to and also of remaining tight when subjected to machine gun and shell fire in warfare, the Air Ministry has arranged a competition for safety fuel tanks, to commence on December 1 next. Three prizes of 1,400*l.*, 400*l.*, and 200*l.* will be awarded and entries, addressed to the Secretary (R.D. 1), Air Ministry, Kingsway, London, W.C.2, must be received on or before November 7. Full particulars can be obtained from the address mentioned, but we may mention that the tank is to be capable of being fitted within a space measuring 2 ft. 6 in. by 2 ft. by 2 ft., and its capacity must be within 5 per cent. of 30 gallons.

THERMIONIC VALVE AS VARIABLE HIGH RESISTANCE.—A simple arrangement for utilising a thermionic valve as a variable high resistance is described by Peter Lertes of the University of Frankfurt, in the *Zeitschrift für Physik*. The cathode filament of the valve is heated by the currents of a 6-volt battery in circuit with a steadying resistance of iron. The main battery of 120 volts is short-circuited by a resistance of 300 ohms. The ends of this resistance are connected by sliding terminals with the anode and cathode, and there is a further sliding terminal leading to the grid of the valve. When the grid potential is slightly varied, while the anode potential is kept constant, the anode current varies on a largely magnified scale, and thus the amplifying valve acts as a variable resistance. With the arrangement described the resistance can be varied within the limits 10^5 to 10^8 ohms. The advantage of the valve resistance is that it is quite free of polarisation and almost free of inductance and capacity. These factors are difficult to eliminate in the case of variable high resistances.

WHITE LEAD IN PAINTING.

ONE of the questions to be discussed at the International Labour Conference, which meets at Geneva, on October 25, is "The Prohibition of the Use of White Lead in Painting." In preparation for the Conferences, it was the duty of the International Labour Office to collect the most relevant and up-to-date information, to summarise it and set it out impartially, and to indicate the various alternative methods of dealing with the problem. The duty of a fair presentation of the facts and arguments for and against prohibition was, obviously, the more cogent because not a few of the Governments and of the representatives at Geneva will have had no previous knowledge of this particular subject, and are, therefore, likely to be guided exclusively by any publication purporting to be official.

Instead of adopting this course, however, the International Labour Office issued to the States that will take part in the Conference a Memorandum and Questionnaire which, it is alleged, is undisguisedly a plea for prohibition. Of this document, Lord Askwith has affirmed that it bears "all the marks of haste and ignorance" and "might be well used as an advertising propaganda of a rival pigment."

Perhaps the most striking example of the partisan character of the document, it is urged, is the assumption in the first item of the Questionnaire: "In view of the fact that it is now technically possible to replace white lead in painting by efficient substitutes." It is right that the facts bearing on this phase of the question should be before the various Governments when considering their attitude, but it is indefensible that they should be invited to consider the matter upon this question-begging statement of a most controversial matter.

The London Chamber of Commerce has now issued a statement of the "Case Against Prohibition," the broad outline only of which is appended. Valuable statistical and other appendices have been omitted for reasons of space.

I.—THE STATISTICS OF LEAD POISONING DO NOT WARRANT PROHIBITION.

It is known that owing to the difficulty of diagnosis of lead poisoning, without special experience, very many cases are wrongly attributed to lead poisoning: thus, tests made by the objective basophilic granulation method confirmed only 38 per cent. of the cases ascribed to lead poisoning by subjective clinical diagnosis. The tendency to attribute to lead poisoning all possible symptoms in a worker who is known or believed to have had anything to do with lead is influenced by the operation of the Workmen's Compensation Act:—"If the individual has been a lead worker, it is easy but frequently erroneous to conclude the symptoms owe their origin to the worker's occupation." (Legge and Goadby: Lead poisoning and lead absorption, page 177.) Even so, the English Departmental Committees which considered the question in 1911, stated that: "The rates of death and attacks due to lead poisoning among housepainters are thus comparatively small." The general health of painters in England is known to compare favourably with that of other occupations. Thus, a comparison of the painters' group (1,851 persons) with a general group (32,033 persons), both of the Hearts of Oak Benefit Society, for one year shows the following results:—

	Percentage Claiming Benefit.	No. of Days' Sickness per Member at Risk.
General Group	18	5·8
Painters' Group	11·1	4·1

There were only one case of sickness ascribed to plumbism, and three cases to colic among the painters' group.

As to death rates, those for the painters' were, at the time of the last Census for which figures are available (1901), lower at every age-period than those of the group "Occupied Males of Industrial Districts."

The death rates are, indeed, lower than in many occupations not usually considered especially dangerous. Mr. J. H. Schooling the well-known statistician, has compared the painter's risk with that of the other occupations as shown in the Registrar-General's Report for 1908 (Cd. 2619), and has stated that the figures show that the mortality among painters "is in no way excessive or abnormal: it has been decreasing as rapidly or more rapidly than the mortality of England and Wales, and there is a very large number of most varied occupations, many of which are believed to be ordinarily healthy in which the mortality exceeds that of painters." While the matter is one which requires the most careful consideration, there is, therefore, reason to believe that the risk of paint-poisoning among painters in England is not more than an ordinary industrial risk.

II.—THERE IS NO EFFECTIVE ALL-ROUND SUBSTITUTE FOR WHITE LEAD IN PAINTING.

Conditions of space make it impossible to set out the technical reasons for the superiority of white-lead paints. Essentially, it is due to its greater durability and hiding power and consequent economy, especially for outside use. The best practical proof of its superiority is the fact that, at any rate within the British Empire, the master painter prefers to use white lead. It is to his interest to turn out good work, and if substitutes had the advantages claimed for them by advertisement and in the pages of the Memorandum of the International Labour Office, they would have long ago superseded white lead upon their merits. Many buildings which during the war were painted with substitutes, owing to the shortage of white lead, are now in a deplorable condition because the substitutes have failed to protect, and have indeed left the surface in such a condition that it is difficult to put on a new protective covering.

III.—THE PROHIBITION OF WHITE LEAD WOULD NOT REMOVE ALL THE CHIEF CAUSES OF PAINTER'S SICKNESS.

If the risks incident to the painter's occupation are to be dealt with effectively, they must be viewed as a whole and all the dangers of the use of paint must be studied as to extent, cause and remedies. (*a*) There is now a great deal of evidence to show that a great deal of painter's-poisoning is wrongly attributed to lead, and is due to the volatile thinners used in paints. The poisonous properties of turpentine, benzol, methyl-alcohol, &c., which are used as volatile thinners with most paints, whether with a base of lead, zinc or anything else, are now well known. To the vapours given off by them immediately upon the application, the painters are continually exposed. This is believed to be the reason for the prevalence of kidney diseases, and especially Bright's disease, and for the frequency of gout, among painters; workers in white lead factories, who are more directly exposed to the dangers of lead, do not commonly suffer from kidney diseases or from gout. (*b*) As to poison from the pigment, the tendency of modern research is to show that poisoning arises from the use of compounds of heavy metals, whether lead or zinc, &c. Modern opinion regards the source of the danger as being, primarily, the inhalation of dust, and, secondarily, paint carried to the mouth by paint-soiled hands, &c., and so absorbed by the digestive canal. The primary importance of dust has been emphasised by nearly all the recent Governmental inquiries, Austrian, Belgian, Geneva, German. Dr. Legge, H.M. Medical Inspector of Factories, in his Report for 1918, summarising the experience of the years of the war, states:—"On the practical side, little more is to be learned as to how lead poisoning is caused, and it can be taken as axiomatic that all risk lies in inhalation of dust or fumes. These removed or prevented, there would be no lead poisoning." This view is strikingly confirmed by the rapid and continuous decrease of cases of lead poisoning in English white-lead factories, and in the Potteries, due to the introduction of regulations to prevent the inhalation of lead dust; *i.e.*, in white lead factories a fall from 399 (1899) to 19 (1919), a decrease of 97¼ per cent., and in the Potteries from 200 (1900) to 21 (1919), a decrease of 90 per cent.

So far as the danger of poisoning arises from the pigment whether from dust or from paint-soiled hands, it can be effectively avoided by simple regulations. One inquiry after another has found that the principal causes of dust are the processes of dry rubbing down and dry scraping of paint: these can be replaced by processes of wet rubbing down. Another source of dust, namely, the drying of paint splashes on overalls, can be avoided by the regular washing of them. The danger arising from carrying paint to the mouth by paint-soiled hands, can be met by instruction of the painters as to the risks of poisoning, and the necessity of proper cleanliness.

IV.—PROHIBITION WOULD BE VERY COSTLY AND WOULD BE DIFFICULT TO ENFORCE AND OF DOUBTFUL EFFECT.

(*a*) *The Cost to the Community of Substitutes.*—The number of structures, machines, and implements which require to be painted, if only for protection, show how large an item of public and private expenditure comes under the heading of "Painting," and how important a consideration is the comparative cost of the use of pigments. The following are some of the facts which cause the use of zinc oxide and leadless paints to be relatively far more costly than that of white lead, it being always borne in mind that labour represents about four-fifths of the total cost: (1) Their inferior "hiding" power necessitates more coats and proportionately more labour; (2) more coats means a larger quantity of paint; (3) their lesser durability necessitates more frequent repainting; (4) repainting is more difficult on surfaces previously painted with substitutes; (5) nothing works so easily under the brush as white lead.

The only seriously suggested substitutes are zinc products; as these are practically foreign monopolies, it is not possible to estimate the prices to which they would rise if white lead were prohibited.

(*b*) *Prohibition would have a disastrous Effect on Home and Imperial Industries.*—(1) The White Lead Industry. Since 85 per cent of white lead is used for paint, prohibition would extinguish the white lead industry in Great Britain, and its workers would be thrown out of employment. In the event of an international prohibition, there would, of course, be no outlet by export; nor would the presence of 4 per cent. or 5 per cent. of lead in the plumbous zinc white advocated by the Memorandum of the International Labour Office materially affect the position. It would not be possible to adapt white lead factories to the manufacture of zinc oxide and other substitutes. White lead manufacturers are large users of certain necessities, such as earthenware pots, timber, spent tan and acetic acid. Their going out of business would adversely affect employment in these industries.

(2) Imperial Lead Mines.—The world's annual production of metallic lead is about 1,100,000 tons, of which 210,000 tons to 220,000 tons, or 20 per cent. are used for conversion into white lead. The great bulk of white lead is used for painting. As zinc oxide is not equal in durability or hiding power to white lead, some 250,000 tons of spelter (crude zinc), or its equivalent in ore, would be required in substitution for the lead used to make white lead.

Deposits in zinc blende (ZnS) pure and simple exist only in relatively small quantities and in limited areas; and these deposits do not occur in the British Empire.

By far the greater part of the blendes used in the making of spelter is produced by working deposits of mixed ores, namely, silver-bearing lead and zinc ores. Such deposits exist in many parts of the world and especially in Australia and Burma; the Broken Hill mine in New South Wales produces 150,000 tons of pig-lead and zinc blendes (representing approximately, 100,000 tons of spelter) yearly, lead ores being the primary product and zinc ores a bye-product.

Prohibition, by reducing the demand by nearly 20 per cent., would inevitably cause a great fall in the price of lead; and, it is stated, would have the effect of closing down the Broken Hill and other mines.

As the zinc industry never has prospered in the United Kingdom and British Empire, the majority of the spelter works and zinc oxide works in the United Kingdom being at present closed, while Belgium and Germany continue to work their factories and smelters and are supplying the British market, the ruinous consequences of putting the British paint industry at the mercy of foreign producers of zinc is but too apparent.

(*c*) If white lead were prohibited and there were no regulations of painting, the painter would still be exposed to the danger of poisoning from turpentine or other volatile thinners; from zinc paint (zinc oxide being poisonous, though to a less degree than white lead); from lead in the use of plumbous zinc oxide, the danger in this case being the worse owing to the worker's false sense of security.

(*d*) If, as proposed, there be permitted the use of plumbous zinc oxide (*i.e.*, zinc oxide made by the "direct" process and therefore containing a small percentage of lead impurity), some system of inspection will be necessary for the enforcement of the prohibition of white lead. As it is easy to cover up under-coats of white lead by a finishing coat of zinc oxide, it would be difficult to prevent the surreptitious use of white lead; this surreptitious use would be more dangerous to the health of the painter than the known and regulated use. This point was dealt with in the Report of the Geneva Commission as follows:—

"It is said that Regulations would necessitate a policeman for every job or for every worker. Would it not be necessary to have far more policemen and inspectors, chemists and experts, to ascertain what there is in the paint pots containing countless mixtures of innumerable products of zinc mixed with lead? Is every coloured pigment containing any proportion of lead to be prohibited? If so, the law would be made of no effect, as will inevitably be the case in France."—(*La Ceruse*, page 74.)

V.—Regulations alone would Effectively Deal with the Cause of Paint Poisoning among Painters.

A.—*Nature of Regulations for Painting.*—(*a*) Regulations to avoid Dust.—Regulations must primarily be directed to the danger of dust, and in particular to dry rubbing down and dry scraping. These should be prohibited.

(*b*) Regulations to ensure Cleanliness.—Next to dust, the chief source of danger of metallic poisoning arises from paint on unwashed hands and face, which may be conveyed into the mouth, especially in the handling of food or tobacco. This danger can be met by provision of the means of cleanliness and enforcement of their use. These may be summarised as follows:—

(1) Provision of washing appliances—water, towels, soap.
(2) Use of overalls and the washing of them.
(3) Ventilation.

(*c*) General Regulations:—

(1) Periodical medical inspection is of special importance, because paint poisoning is slow and cumulative in its effects.

(2) Printed advice explaining the dangers of the industry, with suggestions as to their avoidance, is of importance, because the average painter is frequently found to be indifferent to the dangers incidental to his calling.

B.—*The Machinery of Regulations.*—It is not necessary to elaborate any specific scheme. The machinery of enforcement is an ordinary administrative matter for each country concerned, and does not present exceptional difficulties. It is said that Regulations would be difficult to enforce because the painting industry is one in which men are engaged on many separate jobs for short periods and often in quite small numbers. It is admitted that it is not so easy to enforce regulations in such cases as in a factory industry, but effective enforcement is nevertheless quite practicable. It would be quite unnecessary that every job should be inspected; surprise visits and the rigid infliction of penalties would soon have the desired effect. Regulations for the purity of milk are more difficult to enforce than regulations for painting, although of more vital importance, yet a fairly high standard is maintained without daily visits. The observance of a law does not depend on any certainty that a breach will be detected but upon the knowledge that if discovered it will be punished. It is suggested that the operative Painters' Trades Unions might usefully co-operate in seeing that regulations are enforced, *e.g.*, by officially giving information of breaches.

Governmental Investigations in European Countries.—The subject of lead poisoning has been recently investigated by Commissions of Inquiry in a number of European countries—Austria, Belgium, France, Geneva (State), Germany, Great Britain, Switzerland. With the exception of France and Great Britain (for reasons which the "Case Against Prohibition" shows to be inadequate), all adopted the policy of regulation, and in particular regulations in respect of lead dust.

Of these investigations, that of Geneva was, perhaps, the most illuminating, and its general conclusions may be usefully quoted:—

1. "White lead as used for painting in Geneva does not constitute a social danger necessitating a measure so extreme as prohibition.

"2. White lead is a necessity for which zinc oxide is not an all-round substitute.

"3. Painting with white lead is not a real danger when simple precautions are taken.

"4. Lead dust may be avoided by the use of white lead in the form of paste, *i.e.*, ground in oil (long been a practice in Great Britain), and by preventing dry rubbing down and dry pumice stoning and burning off of old paint."—(*La Ceruse*, pages 17–19.)

It has well been said:—"There is a danger that all ill-considered interference with industry for reasons of hygiene will defeat their own object, and that those very workers whom it is sought to protect, or perhaps an equally important or numerous body of workers, will be deprived of their livelihood. Prohibition of the use of a dangerous article is a mode of dealing with the danger which is, in my view, somewhat childish in its simplicity, and would lead to an almost intolerable interference with the machinery of civilisation if it were applied to all the substances which are of greater danger than white lead."

A former inquiry at Geneva reported that:—"The danger is not sufficient to necessitate the prohibition of a material, the careful use of which does not constitute a social peril. There is an industrial risk, and we do not suppose that it can ever be abolished in painting any more than in any other occupation. At the forge, the slate-quarry, the loom, as a fileworker or a dyer, the worker is exposed to risks often more serious. We do not desire by yielding to the quite natural sentiments of those who are concerned for the workers and demand prohibition, unnecessarily to do the business of certain financial and commercial monopolies and of certain manufacturers of zinc."—(*La Ceruse*, pages 64 and 69.)

FATAL EXPLOSION OF A WATER-TUBE BOILER.

A preliminary inquiry has been made by the Board of Trade under the Boiler Explosions Acts, 1882 and 1890, with regard to an explosion which occurred on December 2 last, at the works of Messrs. C. F. Taylor and Co., Limited, spinners, Shipley, and by which one man, an ash-wheeler named Naylor, was killed. The inquiry was conducted by Mr. Charles Harvey, engineer surveyor to the Board of Trade, and from his report, which has just been published, we have obtained the following particulars:—

The boiler was of the Thompson water-tube type, having three steam drums 4 ft. in diameter by 17 ft. in length, and three water drums 3 ft. 3 in. in diameter by 13 ft. 4 in. in length. Each pair of upper and lower drums were connected by 140 tubes 3¼ in. in diameter and nominally 8 L.S.G. thick. The tubes, some of which were solid drawn, and others stated to be lap-welded, were in straight lengths and were expanded into the drums. Adjacent steam drums were also connected by 30 equalising tubes, and the water drums were similarly connected, having 22 circulating tubes between the front and middle drums, and 13 between the middle and back drums.

The boiler was constructed of steel and was fitted with the usual mountings, the safety valves being loaded to 200-lb. pressure per square inch. It was made by Messrs. John Thompson (Wolverhampton), Limited, in 1919, and was thus about two years old at the time of the explosion.

According to Mr. Harvey's report, a number of repairs at various times, consisting chiefly of the renewal of water tubes and circulating tubes, and of which a list is given, had been made, but we need not give the details of these. The boiler was insured with the Vulcan Boiler and General Insurance Company, Limited, Manchester, and was last inspected by a representative of that company on July 8, 1920. Mr. Hattersley, the works engineer, also inspected the boiler from time to time, and tested it to a hydraulic pressure of 250 lb. per square inch on August 23, 1920, having renewed two tubes a few days previously.

On the occurrence of the explosion, the tenth tube from the left-hand side in the first row of the front bank of tubes, was ruptured longitudinally for a length of 23½ in., at a distance of 6 ft. 7 in. from its lower extremity. The aperture, the greatest width of which was 6 in., was on the side of the tube remote from the fire. The lower end of the tube was drawn out of the drum, and through the openings thus formed the contents of the boiler escaped. There was about 195 lb. pressure on the boiler at the time.

The failure of the tube appears to have been due to the material being in a brittle condition, rendering the tube unfit for the pressure at which it was worked.

In his concluding remarks, Mr. Harvey states that there were three boilers at the works, but only two were on duty at the time, the remaining boiler being then scaled and repaired if necessary. Number three boiler (the one which failed) was last cleaned during the period from May 10 to July 8, 1920, and when inspected by him a few days after the explosion it was practically free from deposit of any kind, there being only a very thin scale on the tubes. The drums were free from deposit, and it is stated that it was the practice to blow a little water out of the lower drums every evening in order to remove any sediment that might have accumulated.

On December 2, the man Naylor came on duty at 7 a.m., and a few minutes before 9 a.m., went into the ashpit in order to clear the same of ashes by throwing them on to the boiler room floor. The pit was 5 ft. wide and 4 ft. 6 in. deep, and so situated that the ashes from the chain grates would be deposited into it when the clearing doors at the end of the grates were suitably operated.

At about 9 a.m. the explosion occurred, filling the boiler room with dense smoke and vapour. The boiler-room staff tried to render assistance to Naylor, but found the ash pit rapidly filling with water liberated from the boiler, while scalding water also poured from the grates making it impossible to remain near the boiler. In the meantime the boiler-room foreman had closed all connections between the No. 3 boiler and No. 2, which was also under steam, thus preventing the flow of steam from the latter to the damaged boiler. In the course of about half an hour the water drained away from the pit, and the body of the deceased man was found near the ladder at the right-hand end.

The tube which failed, the report goes on to say, was of solid drawn steel, and was one of those originally fitted; it showed very little sign of corrosion, the thickness near the fracture being 0·137 in., or 0·023 in. less than the original thickness. The material, however, appeared to be of a brittle nature. A test piece taken from the tube near the line of fracture gave an elongation of 5 per cent. in a length of 8 in., the tensile strength being 31·88 tons per square inch. Bend tests were also carried out, and while the material withstood bending to 180 deg. without fracture, over an axis at right angles to the longitudinal axis of the tube, the pieces failed in all cases, when bent over an axis parallel to the longitudinal axis of the tube, before 90 deg. was reached. Mr. Harvey concludes his report by saying: "The fractures in all the cases revealed streaks of fine and coarse crystalline metal, and I am of the opinion that the material was in an unsuitable condition for the purpose for which it was used."

In his "observations," Mr. Carlton, the engineer-surveyor-in-chief to the Board of Trade, says: "There appears to have been only slight loss of thickness from corrosion of the tube, and in view of the tensile strength of the material and the moderate stresses to which it was subjected, it seems probable that, in addition to the material being rather brittle, the tube was cracked longitudinally. Defects of this nature are very difficult to detect after the boiler has been constructed, and as such defects probably originate in the course of manufacture, very great care is required in the examination and testing of all tubes, both solid-drawn and lap welded, intended for water-tube boilers, to ensure that the tubes are sound and free from flaws, and that the material of the finished tubes has the essential qualities of toughness and ductility.

"It was particularly unfortunate that Learoyd Naylor who was killed, should, in the course of his duties, have been working in the ashpit of the boiler at the time of the explosion, and so received the full effects of the explosion."

Road-Building in Canada.—According to a statement made by Hon. A. MacNab, Minister of Public Works, 7,200 miles of new trunk roads will be built by the Saskatchewan Government within the next three years, and 2,500,000 dols. are to be spent this year on the work.

The Bearing-Metal Genelite.—The bronze "genelite," which has been developed in the research laboratories of the American General Electric Company, is said to have remarkable properties as regards lubrication (*Chemical and Metallurgical Engineering*). The bronze consists of a mechanical mixture of a "synthetic" bronze with 40 per cent. of graphite. The bronze is prepared by mixing the oxides of tin, lead and copper in the desired proportions, with an excess of graphite sufficient partly to reduce the oxides and to leave about 40 per cent. of graphite in the alloy. The alloy is roughly shaped by compression in metal moulds. It leaves the mould in a brittle condition and is rendered homogeneous by a heat treatment and finished by grinding, as it cannot well be machined. The tensile strength of genelite remains very low, but it resists high compression. A peculiar property is that genelite takes up about 2½ per cent. by weight of oil, and can be kept lubricated by capillary attraction, somewhat like a wick. It may thus be sufficient to keep the outside of a bushing lubricated, and for this and other reasons genelite has been found useful, especially to lubricate inaccessible parts of automobile engines.

London County Council: "Archibald Dawnay" Scholarships in Civil Engineering.—The late Sir Archibald Dawnay bequeathed a sum of money to the London County Council for the provision of scholarships tenable in civil engineering courses, and regulations have now been drawn up for the award of the scholarships. One scholarship will be awarded each year to candidates between 16 and 18 years of age who have passed or are exempt from the matriculation examination of the University of London. The scholarships will be tenable for two, or in some cases three, years in the course in civil engineering in the Battersea Polytechnic, Northampton Polytechnic or the Finsbury Technical College. Additional institutions at which the scholarships may be held may be approved in future. The maintenance grant provided will be 110*l.* a year, from which the scholar will require to pay his tuition fees, &c. Candidates will be required to comply with the Council's general scholarship regulations with regard to residence, nationality, &c. The first award will be made early in the autumn term, 1921. Application forms (T. 2/274) may be obtained from the Education Officer, New County Hall, S.E.1, and must be returned to those offices on or before September 24, 1921.

THE VAAL RIVER SCHEME WITH SPECIAL REFERENCE TO THE VAAL RIVER BARRAGE.*

By W. IGHAM, M.Inst.C.E., M.I.Mech.E., Chief Engineer, and J. C. HAWKINS, Assoc.M.Inst.C.E., Resident Engineer of the Barrage.

IN 1886, the Rand was proclaimed as a Goldfield, and in December, 1887, the late South African Republic granted Mr. (now Sir) James Sivewright "the right to lay pipes through the streets of Johannesburg in order to supply the inhabitants thereof with water" from a source which he had acquired on the farm Doornfontein. Among other conditions attaching to this concession, the grantee was obliged to form a Company—subsequently known as the Johannesburg Waterworks Estate and Exploration Company, Limited—and to charge not more than 2*l.* per 1,000 gallons for any water supplied to the public. In 1889, the Waterworks Company had available an estimated supply of about 750,000 gallons per day. To meet the increasing demand of the town and the suburbs, which were beginning to spring up very rapidly, the supply was gradually increased, until in 1893, 862,000 gallons per day were available, although the consumption only average 400,000 gallons per day; in 1895, the yield was increased to 1,470,000 gallons per day, while the demand was 866,000 gallons per day. According to the Census

FIG. 1. VIEW OF PIERS AND APRON.

return of 1896, the population of Johannesburg in that year was as follows:—

Europeans	51,000
Natives	45,000
Asiatics	6,000
Total	102,000

It may be interesting to note that, according to the latest Census return (1921), the population of Johannesburg is:—

Europeans	150,509
Natives	116,569
Asiatics	5,367
Other Coloured	10,459
Total	282,904

In 1897, water rights over the farm Zuurbekom were acquired, and pumping from that source was commenced in the following year. From that year until the transfer of its undertakings to the Board, the company had no difficulty in meeting the requirements of the consumers within the limited area which it then served. The area within the Board's limit of supply is 1,712 sq. miles, and the population within that area is about 550,000, of which about 250,000 are whites.

The total capital expenditure on the Board's works up to date is about 4,050,000*l.*

Prior to 1899, two other companies, namely, the Vierfontein Syndicate, Limited, and the Braamfontein Company, Limited, were formed for supplying water, the first-named to the mines and the latter to the district of Parktown. The Braamfontein Company had available about 100,000 gallons per day from the wells and boreholes at Sans Souci. The Vierfontein Syndicate carried out investigations at that time for water for mining purposes on the farms Vierfontein, Zwartkopjes, Olifantsvlei and other properties in the Klip River Valley and in August, 1899, the syndicate commenced to pump water to the mines from Olifantsvlei, and by the end of that year it was estimated that a supply of about 3,000,000 gallons per day from the dolomite was well in hand, although the actual quantity available was only about 500,000 gallons per day.

A Commission was appointed in 1901, just after the Boer War, and the terms of reference were as follows:—(*a*) To examine the available sources of water supply. (*b*) To prepare a scheme for the creation of an unfailing water supply for the Rand and the mines, taking into consideration future requirements, and (*c*) To consider the constitution of a public body for carrying out and controlling the said scheme. As a result of this Commission, the Rand Water Board was constituted by Ordnance No. 32 of 1903, and the Board was obliged to take over on March 31, 1905, the whole of the undertakings of the Johannesburg Waterworks Company, the Vierfontein Syndicate and the Braamfontein Company. An Arbitration Court was appointed in 1904, with the result that the Board had to pay 2,200,000*l.* for the works in question. Mr. Leitch, M.Inst.C.E., was the first chief engineer of the Board, and under his direction the Zwartkopjes source of supply was developed. In November, 1910, Mr. W. Igham, M.Inst.C.E., M.I.Mech.E., was appointed chief engineer, and the maximum available supplies were then about 8·9 million gallons, and the minimum about 4·9 million gallons per day. Under his direction, the Zuurebkom sources were developed, and the quantity from this area increased from 2·5 million to 7·3 million gallons per day. In addition, temporary water supplies from certain mines on the East Rand were also obtained.

Owing to the increasing demand for water, the Board instructed the chief engineer, in 1911, to proceed with investigations for further supplies. As a result of the chief engineer's investigations into all probable sources of supply within a radius of 50 miles of Johannesburg, he recommended the Board to adopt the Vaal River scheme. In 1913, the Board decided to present a Bill to the Union Parliament for the right to impound in the Vaal River a quantity of water sufficient to provide for a supply of 20,000,000 gallons per day. The Bill was passed in June, 1914, and is known as Act No. 18 of 1914. This scheme was selected by the Board from 21 large schemes reported upon by the chief engineer, and the total cost of these schemes was about 25,300,000*l.*

The impounding reservoir is being constructed to contain 13,633,000,000 gallons of water, and after allowing for all losses due to evaporation and absorption, water below the point of abstraction, and also deducting 1,800,000,000 gallons impounded and reserved for riparian owners, there is 7,500,000,000 gallons available for pumping to the Rand. This quantity gives 20,000,000 gallons per day for one year if no water enters the reservoir. The barrage is being constructed about 25 miles downstream of the Vereeniging Railway bridge, and the length of reservoir is nearly 40 miles. The point of abstraction is about 1½ miles below the railway bridge at Vereeniging, where a river intake and pumping station has been constructed. Vertical spindle centrifugal pumps, driven electrically from the main station, raise the water under a head of 80 ft. through a 33-in. diameter pipe line to the main pumping station, where the water will be treated with sulphate of alumina and allowed to pass through sedimentation tanks and then through "rapid mechanical filters." This method of purification is necessary owing to the finely divided silt which the water of the Vaal River contains. The silt contents ranges from 100 parts to 1,050 parts per million by weight. After passing the filters the water will be sterilised by chlorine produced electrically from common salt. From the main pumping station, steam turbo-centrifugal pumps will raise the water to the Zwartkopjes pumping station, under a head of about 500 ft. through a composite 22-in. and 24-in. diameter pipe line 26·3 miles in length. From Zwartkopjes, the water will be pumped to the Forest Hill reservoir (capacity, 5,000,000 gallons) under a head of 1,100 ft., and to the Leeuwpoort reservoir, under a head of 960 ft. A pipe line will be laid between the Zwartkopjes pumping station and Leeuwpoort reservoir, and this will be composed of 18-in., 21-in. and 24-in. diameter pipes 16·9 miles in length. The new pumping units which are being installed at Zwartkopjes, are steam turbo-driven centrifugal pumps, capable of raising 5·5 million gallons against a head of 1,100 ft.

The following work has already been completed:—Reservoir at Benoni, capacity 2,500,000 gallons, cost 8,760*l.* Reservoir at Signal Hill, Germiston, capacity 2,500,000 gallons, cost 10,196*l.* Pipe line to Benoni reservoir, 12-in. diameter and 12,000 ft. long, cost 10,657*l.* Pipe line from Signal Hill to Simmer and Jack reservoirs, 12-in. diameter and 4,000 ft. long, cost 3,798*l.* Pipe line from Village Main Reef pumping station to Signal Hill reservoir. This is a composite line of 18-in., 24-in., 26-in., 27-in., and 29-in. pipe and 35,500 ft. long, cost 79,179*l.*

Reservoirs under Construction.—One is at Zwartkopjes pumping station, one at Forest Hill, and one at Vereeniging, each having a capacity of 5,000,000 gallons. The accepted tender prices are:—Zwartkopjes, 15,257*l.*, reinforced concrete walls; Forest Hill, 13,113*l.* mass concrete walls; Vereeniging, 11,587*l.*, reinforced concrete walls.

The estimated cost of the Vaal River scheme for engineering only, is 1,580,436*l.*, but the cost of the scheme, after allowing for all charges, will be about 1,750,000*l.* The estimated cost of the barrage alone is 382,000*l.* The scheme now under construction is for a first instalment of 5,000,000 gallons per day. The total capital expenditure after the new scheme is completed will be 5,150,000*l.*

The purpose of this paper is, however, to describe more particularly the construction of the barrage. After an exhaustive survey of the bed of the river, for a length of 130 miles, the site where the barrage is now being constructed, was chosen because there was a good solid rock bottom, and the fall of the river was such that the necessary quantity of water could be impounded with a depth of only 25 ft. at the barrage. It may be mentioned that the fall of the river bed between the barrage and the river pumping station is only 8 ft. in a length of 23½ miles. The pumping station is being constructed at Vereeniging, owing to the proximity of the railway and the coalfields, and also to save a large sum of money in connection with the laying of a pipe line from the barrage. The rock at the barrage site is an outcrop of amygdaloidal-andesite or diabase, which is very hard, dense and brittle, and weighs about 142 lb. per cubic foot. The concrete weighs about 138 lb. per cubic foot.

The barrage consists of a series of steel gates installed between concrete piers. There are 35 piers and two abutments, each 8 ft. thick, 55 ft. long, and 34 ft. 6 in. high. There are 36 steel gates, each 25 ft. high, the clear opening being 30 ft., the gates are 32 ft. 6½ in. wide, being let into the piers for a distance of about 15 in. The weight of each gate is 26 tons, but with the balance weight, operating gear and other appurtenances, the total weight for each opening is about 100 tons. The pressure on each gate is, roughly, 300 tons when the reservoir is full. The gates will be fully raised during periods of high floods, so that the flow of the river will not be obstructed, and the reservoir will be kept free from silt. The average velocity during high flood is about 9 ft. per second. When the gates are raised to their highest position, there will be a clearance of 7·4 ft. above the highest known flood level, which was 26 ft. 6 in. deep at the site of the barrage in November, 1917, and the calculated discharge at that time was 183,000 cub. ft. per second. To enable the gates to be lifted, which, with appurtenances, weigh about 29 tons each, the gate is counterbalanced with a weight just over double that of the gate, and it will be observed that the travel of the counterbalance is only one-half that of the gate. On the top of the piers a superstructure consisting of a reinforced concrete platform supported by reinforced concrete trestle columns is being built. (See Fig. 2.) The gates and counterbalances are suspended from this platform, and the operating gear for the gate is also worked from this level. The height of the platform from river-bed level is 71 ft., and the total height from the bottom of the foundations is about 82 ft. To open a gate, it will only be necessary to withdraw a clutch when the counterbalance will raise the gate to within 2 ft. of the full lift. The operating gear is arranged with a flywheel, which will damp the speed of the gate and, in addition, a special cam, fixed on the winding drums, acts as an automatic brake at the end of the upward travel. The gate will be lifted for the last 2 ft. of its height by means of worm gearing operated by hand. The gate will also be closed by hand by the worm gearing. The time taken to open each gate will be about three minutes and to close it, about 20 minutes. The gate could be raised in one minute, but it is undesirable to raise a gate too quickly, owing to the high velocity of the water having a tendency to erode the apron.

The Union Government has availed itself of the opportunity of constructing a road bridge on the down stream side of the piers, and the Board have undertaken to construct it at cost price, plus 10 per cent. The cost of this bridge will be about 22,250*l.*

The work to be done may be divided as follows:—(*a*) Excavation into the banks of the river to increase the waterway. (*b*) Concrete apron, 4 ft. thick, 100 ft.

* Paper read before the African District Meeting of the Institution of Municipal and County Engineers, at Johannesburg, June 6, 1921.

wide, and 1,376 ft. in length. (c) Concrete piers, 34 ft. 6 in. high, 8 ft. thick, and 55 ft. long. (d) Reinforced concrete low-level bridge for Goliath crane track and footwalk. This crane is for handling the steel gates, which weigh about 29 tons with accessories. (e) Thirty-seven reinforced concrete trestle columns to carry 36 spans of high-level bridge. (f) Thirty-six reinforced-concrete balance boxes, 32 ft. long by 4 ft. 6 in. wide and 8 ft. high, having a total weight of about 62 tons each. (g) Thirty-six steel gates, each 32 ft. 6 in. wide by 25 ft. high, together with all the accessories. (h) Re-inforced-concrete road bridge, 1,400 ft. long and 36 ft. above the level of the apron.

Excavations.—About 275,000 cub. yards have been excavated in rock, shale, clay and earth. The object of cutting into the banks of the river was to increase the waterway to compensate for the area taken up by the concrete piers, so that there shall be no question of the piers obstructing the natural flow of the river in flood time. The additional waterway thus created is about 40 per cent. greater than the original area.

The Rock Excavation was carried out by means of rock drills, chiefly of the Flottman type, operated by compressed air (pressure, 75 lb. per square inch at com-pressor), and the earth on the O.F.S. bank was removed hydraulically. The plant required for the latter opera-tion included a Sulzer centrifugal pump and a 250-h.p. steam engine. A Renold's chain was used for driving the pump, and it worked in a very satisfactory manner. Water was pumped from the river through a 15-in. main, having three 8-in. branches. The ends of the 8-in. branches were provided with monitors having 1¼-in. and 1¾-in. nozzles, and the water pressure was main-tained at about 80 lb. per square inch at the jet. The centrifugal pump was capable of supplying 2,100 gallons per minute. This method was found to be cheap and expeditious for removing the earth and soft clay. The rock at the barrage site is continuous across the river and no difficulties were encountered with the foundations. In blasting the rock in the river bed, only shallow holes were put down, the bottom of which were never less than 9 in. above the finished level. This depth, 18 in., was most suitable for this class of rock, and it was found that by using small charges that the rock was not shattered.

River Diversion.—Generally, the principle adopted was to dam off sections of the river bed by coffer dams commencing at the Transvaal side and working south. Concrete walls were constructed for the upstream side, and clay core walls for the cross and down-stream walls. The latter walls were cheap and easy to replace, and in large floods were washed away and gave a free way for the silt being carried down the river. These clay core walls were of two types:—(1) Two rough stone walls were built up about 1 ft. high with a space of 1 ft. between them, and the space filled with clay and well rammed. This operation was repeated until the desired height was obtained. (2) Cement bags filled with rubble and earth taking the place of stone walls and clay puddle between them. The upstream concrete wall was not built continuous, but gaps were left in it, into which concrete slabs 6 ft. wide and 2 ft. 3 in. deep could be fitted, allowing the gaps to be opened or closed at will, so that in the event of a freshet coming down the river some of the slabs could be taken out, to prevent flooding if concrete work was in progress. To enable work to proceed during freshets, cross walls were built at frequent intervals to prevent the flooding of the whole area.

Concrete Work. Apron.—The apron (see Fig. 1) covers the rock bed for the entire length of the barrage and for a width downstream of 100 ft. Its purpose is to prevent erosion of the foundations under and downstream of the piers, and for this reason is carried 45 ft. beyond the back of the piers. It may be as well to mention that great care should be taken to avoid erosion downstream of a dam or barrage, bearing in mind the costly experience at the Assuan dam. The average thickness of the apron is 4 ft., and the concrete mixture was 1-3-6, except for the top 6 in., which was 1-2½-5. Drains were constructed under the concrete, downstream of the gate sills to prevent any upward pressure on the apron. Whenever possible, the concrete was put in, for the full thickness of the apron and one day's concreting varied from 100 cub. yards to nearly 300 cub. yards. About 25 per cent. of displacers or plums were placed in this concrete. In order to bring the concrete to a good surface, the shuttering for each day's work was accurately levelled and when the concrete was brought up to surface level, it was rolled with a 4-in. pipe, this 4-in. pipe was 23 ft. long, and the smallest dimension for the days patch' was always kept 2 ft. less than the length of the pipe, so that the pipe could be rolled along the top of the level shuttering or screeds. This method of finishing off proved very effective and cheap, as it not only gave a level surface, but squeezed out excess water and laitance.

On the downstream edge of the apron a dwarf wall 3 ft. high has been constructed to form a pond at the back of the gates, and thus break the velocity of water when the gates are being opened, cross walls 3 ft. high have also been built from the end of every fourth pier to the dwarf wall erected at the downstream edge of apron so as to prevent cross currents.

Piers.—There are 35 piers and two abutments built as at 38-ft. centres. They are 8 ft. thick, 34 ft. 6 in. high and 55 ft. long. The foundations for the piers were carried at least 12 in. into the solid rock below the apron foundation, and the concrete was of 1-2½-5 mixture. The maximum depth of the pier foundations was about 6 ft. below the surface of the rock. All piers were built up in 6 ft. lifts, with 6-ft. by 3-ft. wooden shutters, and these proved to be a very useful and handy size. For the first lift the shutters were braced to the apron, and to provide for the successive lifts bolts were cast into the concrete 10 ft. apart and 6 in. below the top of the shuttering. This method left a clear opening between piers for the discharge of floods, and enabled the form work to be put up and dismantled at all times, providing, of course, that the river was flowing below the level of the last batch of concrete.

Reinforced Concrete.—All reinforced concrete is at least 35 ft. above the level of the apron. The whole of the materials for the reinforced concrete have been proportioned on the Duff Abrams method for the "Design of concrete mixtures," and at present the proportions used are 1-1·64-4, with a water ratio of 0·72 cub. ft. of water to 1 cub. ft. of cement and a relative consistency of 1·10. It should be mentioned that all crushed stone is saturated with water during crushing, so that the only water used subsequently is for the hydra-tion of the cement. The sand does not absorb much moisture, as it is almost pure silica. Where the rein-forcement is close together and there is little space for concrete, as on the tension side of the beams, a slightly wetter mixture is used in order to facilitate the filling, and the stone is screened through a ¾-in. sieve.

Reinforced Concrete for Low-Level Bridge.—The low-level bridge consists of two lines of straight girders, 37 ft. 10 in. long, 4 ft. high and 16 ft. thick, each weighing 14 tons, and with a clear span of 30 ft. These girders are designed to carry a Goliath crane capable of trans-porting a 30-ton load. A smaller girder weighing 7 tons will carry one side of a foot bridge, and the other side is carried by one of the 14-ton girders. The smaller girders were all cast on the Transvaal Bank and after two months were placed *in situ* and the larger girders were cast on the top of them. This was done to save the expense of building a gangway to carry the big girders. It was found that the large girders required a setting time of six weeks before they could be lifted without showing any deflection.

Superstructure Columns for High Lever or Operating Bridge.—On account of the rapid filling of the small quantities of concrete required for this work it was found that the pressures would be too great if a whole form was filled to its full height in one day unless the forms were strengthened considerably, and this would considerably increase the cost of the falsework. Owing to there being plenty of concrete work to go on with, these forms were filled in two stages, at intervals of 12 hours between each, and at the end of seven days the false work was removed. The only factor which pro-hibited the removal of the forms in less time was the large cross beams required for bracing. As will be seen in Fig. 3, the false work for the concrete for the high-level bridge is carried on trussed timber beams (35 ft. spans) at a height of 70 ft. above apron level. These timber trusses are designed to carry 10 tons with a deflec-tion of 1 in., and are carried on eight steel-pipe supports each 27 ft. high. The total load of wet concrete and falsework per span is 64 tons. All falsework is designed with a view to rapidity of erection, dismantling and re-erection, and for use many times over without being unduly damaged. It was found that four sets of shutter-

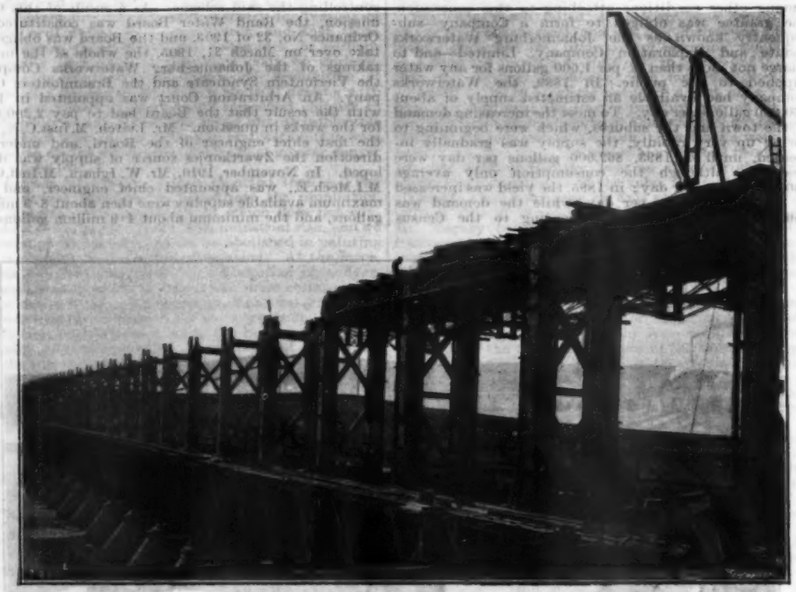


Fig. 2. Piers and Superstructure.

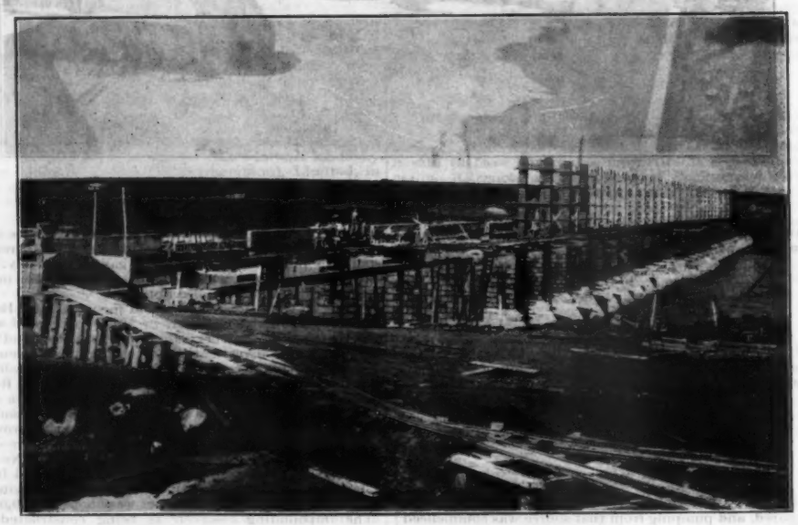


Fig. 3. Erection of Piers and Bridge.

ing were sufficient for the 37 columns with occasional renewal of the boards.

Balance Boxes.—These will be cast *in situ* as soon as the false work for the high-level bridge is struck. Two of the trussed beams used for the high-level bridge will then be lowered to the piers and the falsework for the balance boxes erected on them. Each box has six compartments, with 5-in. outside walls and 5-in. partition walls. The compartments are each 4 ft. 2 in. by 2 ft. 8 in. by 7 ft. 3 in. deep. These compartments will be filled with stone and sand to make up the requisite weight for balancing the gates. The angle iron used in the design of the falsework will subsequently be used for the hand-rail stanchions on the high-level bridge.

Steel Gates.—The steel gates will be of the free roller type, and will be operated by hand in single units. A complete gate will consist of eight steel bow string trusses, each 31 ft. 7 in. long by 4 ft. 6 in. deep in the centre, spaced and joined by ½-in. steel skin plates. Each gate will weigh 26 tons and will have a travel of 34 ft. or 7 ft. 4 in. higher than the highest known flood. The operating mechanism will consist of:—(1) A balance box, weighing about 62 tons, which is attached to the gate by wire ropes. (2) Conical drums, around which the wire ropes attached to the balance box are wound. (3) Operating headstocks.

To raise the gates it will merely be necessary to withdraw a clutch which allows the balance weight to come into action. The design of the mechanism is such that the maximum accelerating force is exerted at the commencement of the travel of the gate. Once movement has been started, the velocity continues to increase until the gate has travelled through a distance of from 12 ft. to 15 ft. according to the setting. Thereafter on account of the conical shape of the winding drums a change takes place and the velocity commences to diminish and continues to diminish until the gate comes to rest. When the gate reaches its highest position, it has a tendency to reverse its direction of motion and pawls drop into rachet wheels and lock the gate in position.

Reinforced-Concrete Wagon Bridge.—The Public Works Department wagon bridge will be constructed in units of four spans to the type of designs of the Public Works Department. The shuttering will be carried on three trussed beams and the total weight of concrete and false work may be taken at about 52 tons per span.

Concrete Blocks.—The base on which the Public Works Department bridge is carried is faced with concrete blocks, which were cast in moulds on shore. These blocks were made to save labour and timber. Blocks were also used for the upstream nosings of piers. They weighed from 90 lb. to 1,200 lb. each, and specially hard faces were made by means of a plasterer's steel float. The material forming the body of the blocks was in the ratio of 1-3-6 and the concrete was well rammed and made with very little water. The top ½ in. was of sand and cement, also made fairly dry, and as much pressure as possible was put on at each stroke of the float. If too much work is put on these faces, the uncombined material in the cement is brought to the surface and eventually forms a thin film, which in setting, exhibits itself by the presence of hair cracks. The moulds in this case were removed in from 12 hours to 24 hours.

Transport.—All transport is brought from Vereeniging by ox wagon at 9s. per ton. This has been a considerable item, which will be realised when it is stated that everything except stone and sand has been delivered via Vereeniging to the Barrage Works.

Plant.—The plant for construction includes:—One 110-h.p. B. and W. boiler; one 100-h.p. Allis Chalmers air compressor compressing 600 cub. ft. of free air per minute to 75-lb. pressure. Three concrete mixers (2 Ransomes, 1 Standard); three stone crushers; two portable engines with boilers; 8-ft. metal planing machine. Numerous small engines, pumps, etc., which are for the most part driven by compressed air.

From experience gained on these and other works, it is found that compressed air is more suitable than any other form of power, as it can be utilised for so many purposes.

Buildings.—The permanent buildings, required after the completion of the barrage, were built in 1916, and the other buildings which are only of a temporary nature are built of sun-dried bricks, and will be demolished when the barrage is completed.

Labour Employed.—At the present time 49 Europeans (of which one-third are carpenters) and 250 natives are engaged on the work, but the maximum number of natives employed at any one time was 600.

Recreation.—The Rand Water Board have generously provided the camp with assistance by the provision of a billiard table, library, tennis court, golf course, and a rifle club attached to the Defence Department.

The authors desire to acknowledge the excellent work of Mr. C. E. Mason, the principal electrical and mechanical engineering assistant, and Mr. M. Udwin, chief civil engineering assistant, in connection with the scheme, and also take this opportunity of thanking the chairman, the secretary and engineering and secretary's staff for their willing help at all times.

INFLUENCE OF CERIUM ON ALUMINIUM AND ITS ALLOYS.—Some years ago, O. Barth claimed to have improved the mechanical properties of aluminium by the addition of cerium, used in percentages up to 11. The further investigations of Josef Schulte, also conducted at the Technical High School, Aachen, (*Metall und Erz*), only partly confirm Barth's observations. Schulte found the elongation of aluminium was raised to 34 per cent. by the addition of 0·2 per cent. of cerium; the tensile strength was not increased, and larger additions of cerium were almost useless.

THE SEASON-CRACKING OF BRASS AND OTHER COPPER ALLOYS.*

By H. MOORE, O.B.E., B.Sc., F.I.C., Member; S. BECKINSALE, B.Sc., A.I.C.; and CLARICE E. MALLINSON, M.B.E., B.Sc.

(Communication from the Research Department, Woolwich.)

(*Concluded from page 299.*)

THE ACTION OF MERCURY AND OF AMMONIA ON BRASS AND THE USE OF MERCURY FOR THE DETECTION OF STRESS.

Evidence indicates that mercury, and also ammonia, acting on stressed brass which is liable to fail by season-cracking, produces in a short time cracks of a nature very similar to, if not identical with, season cracks. Peculiarities in the behaviour of surface layers, when submitted to the action of mercury or ammonia, have also been indicated.

The most convenient way of applying mercury is by immersion in solutions of mercury salts. Copper and zinc replace mercury in the solution, and the mercury is deposited on the surface of the brass. While the possible effect of the removal of a certain amount of brass from the surface by this reaction should not be overlooked, it is highly probable that the cracks are produced by the action of the metallic mercury itself.

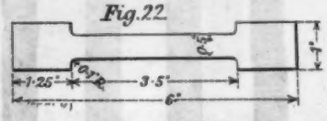
The material used in this section was 70 : 30 brass and copper of a high degree of purity. Except where otherwise stated, the test-pieces were of strip form cut with their length parallel to the direction of rolling; the dimensions are shown in Fig. 22.

In all cases in which the hardness was above that of well-annealed brass (40 to 60 Brinell number), the strip had been cold-rolled to the hardness stated and had not been subsequently annealed except in a few cases where annealing is specifically mentioned.

1. *Effect of Variations in the Mercury and Acid Contents of Solutions applied to Brass.*—The presence of some free acid accelerates the action of solutions of all mercury salts which have been tried and produces a better coating of mercury.

Two series of tests were carried out with mercurous nitrate solution. Two similar series of tests were made

Fig. 22.



with solutions of mercuric chloride and hydrochloric acid. The concentrations of solutions used are expressed as follows throughout this paper:—

Mercurous nitrate. Percentage by weight of crystals $Hg_2(NO_3)_2\,2\,H_2O$.
Mercuric chloride. Percentage by weight of crystals $HgCl_2$.
Nitric acid. Percentage by volume of nitric acid 1·42 specific gravity.
Hydrochloric acid. Percentage by volume of hydrochloric acid 1·2 specific gravity.

Two cups spun from fully annealed brass and two tensile test-pieces cut from fully annealed strip were immersed in each solution for 5 minutes. The standard pickling treatment had previously been applied, and the ends of the tensile test-pieces had been coated with paraffin wax to preserve them from the action of mercury, which was thus restricted to a length of 3 in., 500 c.c. of solution were used for each cup and 100 c.c. for each test-piece. After washing the strip, test-pieces were broken in 45 seconds to 60 seconds, the longer times being taken by the test-pieces with the greater elongations, and 60 seconds was the time required to break the test-pieces of circular section.

All the mercurous nitrate solutions and the solutions containing 0·97 per cent. mercuric chloride with 5 per cent., 10 per cent. or 20 per cent. hydrochloric acid, gave a bright coating of mercury. The mercuric chloride solutions in which the ratio of acid to mercuric chloride was lower, produced a coating which was bright when first formed at the moment of immersion, but soon became covered with a dull deposit of mercury in the grey form. In the stronger chloride solutions the deposit of mercury was almost black. Deposits of grey mercury obscure cracks, although a bright coating remains if the grey deposit is removed.

The test-pieces were free from cracks before loading. Fig. 23 is a photograph of the strip test-pieces broken after mercurous nitrate treatment. The transverse cracks formed during loading were less numerous as the concentration of the mercury solutions increased. In general, the amount of mercury deposited increased with increase in concentration of mercury in the solution. When a sufficient excess of mercury had been deposited on the surface, the mercury penetrated through the test-pieces during the development of the cracks in loading, but when the deposit was smaller only the outside layers of the test-pieces were affected, the interior elongating and finally breaking with a fibrous fracture.

In the mercurous nitrate tests on the spun cups the rapidity of the cracking effect increased considerably with increase in mercury content, while the effect of variation in nitric acid content was small. A solution containing 1 per cent. mercurous nitrate and 1 per cent. nitric acid produces cracks in about 30 seconds, and no practical advantage is gained by using stronger solutions. Mercuric chloride solutions are slower in their action.

These series of tests demonstrated the advantages of mercurous nitrate solutions and the suitability of a solution containing 1 per cent. mercurous nitrate and 1 per cent. nitric acid as a reagent for detecting internal stress.

2. *Effect of Variation in* (a) *Hardness of Brass*, (b) *Lapse of Time after Treatment with Mercury or Ammonia.*—Strip tensile test-pieces (Fig. 22) 0·05 in. or 0·1 in. thick were prepared from fully annealed 70 : 30 brass and copper and from strip cold-rolled to the hardness of between 62 and 186 Brinell and not subsequently heat-treated. The test-pieces were pickled in nitric acid, and the ends were coated by dipping in molten paraffin wax as before. A uniform rate of loading was maintained in the tensile tests.

The mercury treatment consisted in immersion for 5 minutes in a solution containing 1 per cent. mercurous nitrate and 1 per cent. nitric acid (1·42 specific gravity). During the stated period between mercury treatment and loading in the testing machine the test-pieces were kept in a small airtight space; this is of some importance in connection with the possibility of volatilisation of mercury. The free mercury on the surface was in no case absorbed by the brass.

In the ammonia treatment the test-pieces were stored for the periods stated in a closed space, containing some air, over 0·880 ammonia solution. The ammoniacal atmosphere had access to all parts of the surface of the test-pieces except the paraffin-coated ends. The test-pieces quickly tarnished and were soon coated with a dark blue liquid and corrosion product.

Some test-pieces differed from others only in being subjected to a low-temperature annealing before exposure to mercury or ammonia, were tested in the same way. The annealing applied (at 250 deg. to 300 deg. C.) was adjusted in each case to bring about a small but distinct drop in hardness; such treatment greatly diminishes, if it does not completely remove, any internal stress present.

In another series of tests the mercurous nitrate solution contained 5 per cent. mercurous nitrate and 5 per cent. nitric acid. The results were practically identical.

3. *Effect of Variation in Rate of Loading of Test-Pieces previously Treated with Mercury.*—Strip test-pieces of annealed 70 : 30 brass and of hard-rolled brass were pickled and treated with a solution containing 1 per cent. mercurous nitrate and 1 per cent. nitric acid as previously described, and were at once transferred to the testing machine. The rate of loading of different test-pieces varied from about 2 seconds to about 7 minutes per ton per square inch. In each test the rate of loading was carefully controlled and was uniform. The effect of rate of loading was very marked in the tests on annealed brass, the test-piece loaded in 45 seconds giving a maximum stress of 10 tons per square inch and 23 per cent. elongation, the test-piece loaded in 25 minutes giving 3·8 tons and 7 per cent. The results suggest that the effect of the mercury on an unstressed test-piece before loading is confined to a very thin surface layer, that free mercury on the surface penetrates the cracks formed in this skin at low stresses, and that if sufficient time is allowed, the mercury penetrates through the brass by the gradual extension of cracks into which the mercury flows. In the tests on hard-rolled brass (approaching in hardness the maximum attainable in 70 : 30 brass by cold-work) there was very little effect, and the effect of mercury treatment was small in all the tests.

In view of these results it was thought that single-blow impact tests on notched bars might throw some light on the depth to which the weakening effect of mercury and of ammonia penetrates in unstressed brass. Test-pieces, 10 mm. wide by 5 mm. deep, notched to half their depth by a 45 deg. V-notch of 0·25 mm. root radius, were used. Test-pieces of 70 : 30 brass of Brinell hardness 60, 90, 155 and 190 and cast brass (Brinell hardness 53) of the same composition were pickled and treated with 1 per cent. mercurous nitrate solut on; they were broken immediately and at 1 hour, 1, 7, 21 and 180 days after treatment. Free bright mercury remained at the bottom of the notch throughout storage, up to the maximum period of 180 days, and was present when the test-pieces were broken. Identical test-pieces were stored in a closed space over 0·880 ammonia for 1, 7, 21 and 165 days and broken; much corrosion had occurred in the longer treatments over ammonia. Untreated test-pieces were also broken in all cases. The tests were made in the 30-kg.m. Charpy machine. In none of these tests was the energy absorbed affected to any marked extent by the mercury or ammonia treatment, the figures remaining approximately constant throughout each series. The results confirm the view that in unstressed brass the embrittling effect of mercury or ammonia penetrates to a comparatively shallow depth even after long exposure, but the depth to which the weakening effect can penetrate is decidedly greater with ammonia than with mercury.

4. *Recovery of Properties of Mercury-Treated Brass on Removal of Mercury.*—Two test-pieces from 70 : 30 brass of each hardness used in the tensile tests were pickled and treated in 1 per cent. mercurous nitrate solution as previously described. The test-pieces were stored in a closed space for seven days, and were then placed in an air oven at 200 deg. C. for 48 hours in order to volatilise the mercury. After this treatment no mercury was visible on the surfaces of the test-pieces. Chemical tests applied to the broken test-pieces showed that they were quite free from mercury.

5. *Determination of Minimum Stress Detectable by Mercury Treatment.*—In the first instance mercury treatment was applied to strip maintained in simple tension by a known load. Strip seemed the most appropriate form for such tests, as resembling as closely as possible the stretched external layers of objects liable to develop season cracks. The test-pieces were pickled, and a given load was applied in a 5-ton testing machine.

* Abstract of a paper read at the meeting of the Institute of Metals on Thursday, March 10, 1921.

The surfaces of the test-piece were gently rubbed with cotton-wool soaked in mercurous nitrate solution, the application being continued for 5 minutes unless fracture occurred in a shorter time. In some series a solution containing 1 per cent. mercurous nitrate and 1 per cent. nitric acid was used, in others the solution contained 5 per cent. mercurous nitrate and 5 per cent. nitric acid. The time at which the test-piece broke was recorded.

6. *Mechanism of the Action of Mercury and Ammonia on Brass.*—Many observations have been noted above indicating that mercury and ammonia, like the agencies which produce season-cracking in stressed brass, cause an intercrystalline weakening, resulting in the development of cracks between the crystals. The experiments now to be described were intended to throw light on the mechanism of this intercrystalline weakening.

Experiments on very Coarsely Crystalline Brass.—70 : 30 brass containing crystals not less than 0·20 in. across (described below as very large crystals) was obtained by annealing hard-rolled strip for 48 hours at 900 deg. C. This treatment did not always give the desired result; among pieces of brass from the same strip which had been treated together some would have the large crystals desired, others had crystals only about 0·05 in. across, while other pieces contained large crystal areas in a ground mass of smaller crystals. These variations were, no doubt, due to variation in the initial deformation of the crystals. Since this work was done much light has been thrown on the problems of crystal growth by H. C. H. Carpenter and Miss C. F. Elam.*

In many of the tensile test-pieces prepared a single crystal extended completely across the test-piece. The test-pieces were etched to locate the crystal boundaries. In the specimens exposed to the action of ammonia the position of the boundaries was recorded by means of measurements, while in the test-pieces treated in mercurous nitrate a record of the position of the boundaries was preserved by drawing fine scribed lines parallel to and at a distance of 0·02 in. from the boundaries.

After etching, the ends of the test-pieces were protected by paraffin wax. Test-pieces were broken: (1) Without further treatment. (2) After exposure in a closed space over 0·880 ammonia solution for various periods. Before the load was applied the dark blue liquid was wiped off the test-piece; the solid coating of corrosion product flaked off during loading. (3) After treatment with 1 per cent. mercurous nitrate solution and storage in a closed space. The periods were taken as the intervals between treatment and loading.

Some test-pieces had very large crystals; others had crystals measuring about 0·05 in. across, whilst some had large crystals in a ground mass of smaller crystals. In this series of tests the lines followed by the fractures and the certainty with which the crystal boundaries were identified in the test pieces before and after breaking showed definitely that the paths of the cracks produced by straining the test-pieces previously acted upon by ammonia or mercury were intercrystalline.

The coating of mercury obtained by the mercurous nitrate treatment remained on the surfaces of the test-pieces so treated during storage, and also during loading, except in two test-pieces. Before loading, the mercury was removed from the surface of these two test-pieces by polishing, followed by light pickling with nitric acid. The much higher maximum load and elongation, and especially the entirely different nature of the fracture given by these said two test-pieces, suggest very strongly that in the other specimens the penetration of the mercury along the crystal boundaries took place during and not before loading.

The results given by all the mercury-treated pieces indicated that when mercury was present on the surface of coarsely crystalline brass during loading, the crystals were separated by tension and the fractures, consisting of crystal boundaries, became coated with mercury. In order to ascertain whether mercury had diffused into the interiors of the crystals, single crystals separated from broken tensile specimens and coated with mercury were examined by first removing all external mercury by rubbing with fine emery paper, and then testing the remaining crystal chemically by a method (described in the appendix) capable of detecting 0·00002 gramme of mercury. The results proved the interiors of the crystals to be wholly free from mercury.

The type of intercrystalline surface cracking given by ammonia-treated test-pieces is shown in Fig. 24. In all test-pieces giving an intercrystalline fracture after ammonia treatment, and in all fractures in stressed brass definitely known to have been induced by ammonia, the intercrystalline parts of the fractures bore a characteristic iridescent tarnish, bright golden in colour in its early stages. There is a marked difference between the action of ammonia and that of mercury in that the intercrystalline weakening caused by ammonia penetrates the brass to an appreciable depth during periods of exposure to ammonia, while the action of mercury is very superficial until cracks form allowing penetration.

7. *Some Further Observations.—Replacement of Copper and Zinc by Mercury.*—Specimens of fully annealed 70 : 30 brass (surface area about 340 sq. cm., weight about 70 grms.) were pickled, washed, dried, and weighed, and were treated for five minutes in 1 per cent. mercurous nitrate solution, washed, dried, and weighed again. The specimens were then heated at 400 deg. C. for forty minutes in a current of hydrogen to drive off the mercury, cooled in hydrogen, and again weighed. No further loss of weight occurred after a further heating, this time at 450 deg. C. The results are given below.

Specimen.	1.	2.
	grm.	grm.
Weight of mercury taken up ...	0·2043	0·2160
Weight of mercury taken up per sq. cm.	0·00061	0·00064
Weight of zinc replaced ...	0·0160	0·0160
Weight of copper replaced ...	0·0245	0·0245

The proportion of zinc to copper dissolved is slightly higher than the proportion in the brass. The weight of mercury deposited is a little less than that required to replace the copper and zinc dissolved. Parallel experiments on hard-rolled and on annealed 70 : 30 brass indicated that the difference in the weight of mercury deposited in the treatment in mercurous nitrate solution, as described above, was very slight. On specimens having an area of 57 sq. cm. the average gain in weight was 0·0338 grm. for fully annealed, and 0.0318 grm. for hard-rolled brass, duplicates giving very close agreement.

Immersion of Brass and Copper in Mercury Baths.—Strip tensile test-pieces of copper and 70 : 30 brass were pickled and treated with 1 per cent. mercurous nitrate solution in the manner described previously, the ends being protected by a wax coating. The mercury-coated pieces were then placed in a bath of clean mercury and withdrawn after 320 days' immersion. The unwaxed surfaces were found to be coated with mercury and uniformly pitted. The mercury was shaken off and the layer of friable amalgam scraped off. The test-pieces were rubbed with emery cloth and paper until no mercury could be seen on the surface and all the pits were removed. The test-pieces, after measurement, were broken, together with test-pieces originally identical but not treated with mercury.

Pieces of the broken test-pieces were tested for the presence of mercury by the chemical method described in the Appendix, capable of detecting 0·00002 grm., and found to be quite free from mercury. The mercury in which the test-pieces had been immersed contained traces of copper and zinc; the scum on the surface of the mercury consisted of oxides of mercury and zinc with a trace of copper oxide.

In these experiments the action of mercury on brass appears to have been: (1) The formation of a thin layer of an alloy (amalgam) of mercury, copper, and zinc on the surface of the brass. (2) The gradual growth of this layer and the removal from it of zinc by solution in the mercury bath, the zinc being gradually oxidised at the surface of the bath. The copper-mercury alloy left on the surface of the brass probably protected and stopped further mercury attack at some stage.

It is evident that no diffusion or penetration of mercury to any appreciable depth in the brass or copper occurred.

Microscopic Examination of Brass treated with Mercury and with Ammonia.—Numerous attempts were made to investigate the action of mercury on brass by microscopic examination of sections prepared in various ways, but owing to the impossibility of preventing the smearing of mercury over surfaces by polishing no useful results were obtained. Whenever cracks caused by mercury action were examined, they were found to follow an intercrystalline path. Many specimens of both stressed and unstressed brass treated with ammonia were examined microscopically after various forms of treatment and methods of preparing the section. In all cases, wherever ammonia had acted, an effect on the crystal boundaries was observed, ranging from a distinct widening to the opening of actual cracks. Actual separation of the crystals occurred in unstressed brass after sufficiently prolonged action by ammonia.

8. *Summary.*—Treatment in solutions of mercury salts causes the deposition of free metallic mercury on brass; the weight of mercury deposited is much greater than the weight of copper and zinc dissolved. The alloying action is confined to a very thin surface layer of the brass. The disappearance of mercury from the surface, through lapse of time, which has been attributed by some workers to diffusion of mercury into the brass, is apparently due, mainly if not wholly, to volatilisation of the mercury, and is prevented or greatly retarded by storing treated specimens in a small closed space.

Treatment with mercury before loading causes the failure of a tensile test-piece, when loaded, by the development of surface cracks, reducing the maximum load and elongation. The experiments on coarsely crystalline brass showed that in this material the cracks started at crystal boundaries on the surface of the specimen and followed the crystal surfaces, which became covered with mercury. It was proved that the mercury was not present in the crystal boundaries, except at the extreme surface of the specimen, before the development of cracks. It is probable that the action of mercury is similar whatever the size of crystal, and in all cases which have been examined cracks resulting from the action of mercury have been intercrystalline.

In general, mercury appears to induce an intercrystalline weakening in brass. The observed facts can most readily be explained in the following way. Mercury acts selectively on the intercrystalline material, weakening it (probably by forming a weak alloy) to a very small depth from the surface coated with mercury. If this surface layer is submitted to a tensile stress the weak mercury-affected intercrystalline material gives way and intercrystalline cracks form. Mercury penetrates these, and its weakening effect on the intercrystalline material thus extends to a depth depending on the amount of free mercury and the length of time available for penetration. If the rise of stress is so rapid or the amount of mercury so small that the penetration of mercury into the cracks

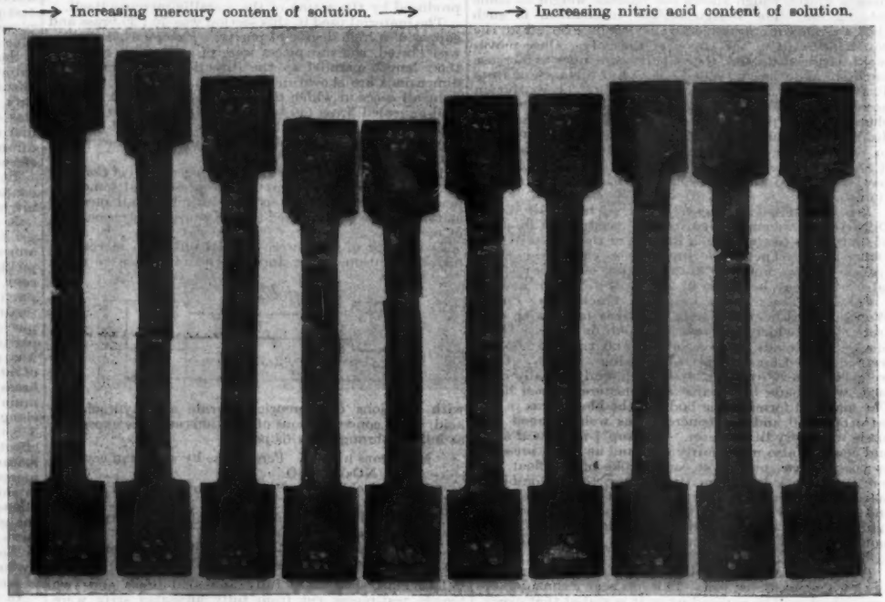


Fig. 23. Broken Strip Tensile Test-Pieces, 70 : 30 Brass, Treated, before Loading, in Mercurous Nitrate Solutions.

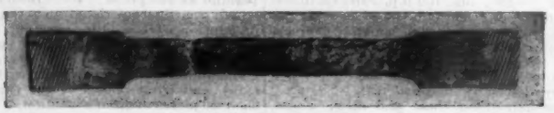


Fig. 24. Broken Strip Tensile Test-Piece, 70 : 30 Brass, with Large Crystals. Exposed over 0·880 Ammonia before Loading. Showing Intercrystalline Cracks in Surface.

* H. C. H. Carpenter and Constance F. Elam, "Crystal Growth and Recrystallisation in Metals," Journal of the Institute of Metals, No. 2, 1920, vol. xxiv, page 83.

cannot keep pace with the increasing stress the crystals stretch and are pulled out into the usual fibrous fracture, accompanied by large distortion of the neighbouring material.

The effect of mercury becomes less as the hardness of the brass is increased by cold-work. It would appear that with increasing cold-work hardness the mercury produces less intercrystalline weakening, although in medium hard-rolled brass intercrystalline fractures are still produced readily by the action of mercury.

This view of the mode in which mercury weakens brass is in agreement with (1) the greater effect of heavier mercury deposits; (2) the small effect of lapse of time between mercury treatment and loading; (3) the marked effect of rate of loading on mercury-treated specimens; in the annealed test-pieces slow loading, favouring the progress of the weakening action of mercury described, reduced the tensile strength and elongation to very low figures; (4) the absence, in notched bar impact tests, of any important effect of mercury treatment; the rise of stress was much too rapid for the intercrystalline weakening effect of mercury to keep pace with it; (5) the disappearance of the effect of mercury on unstressed brass when the mercury was removed; (6) the absence of mercury from the interior of large mercury-coated brass crystals, and generally the behaviour of coarsely crystalline brass under mercury treatment.

The weakening effect of mercury, acting in this way, explains its action in detecting stress. A surface layer in tension, if weakened at the crystal boundaries, develops

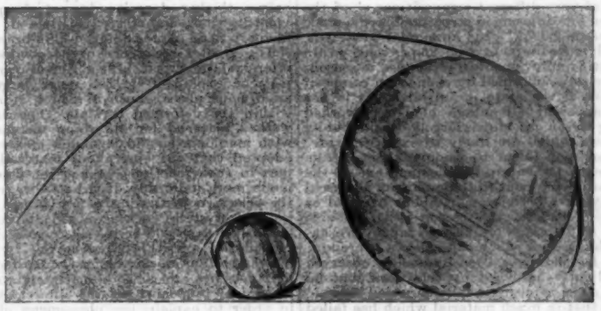


FIG. 25. BRASS (70 PER CENT. COPPER) CONTAINING 3 PER CENT. OF MANGANESE, STRESSED BY BENDING ROUND CIRCULAR WOODEN BLOCKS AND BROKEN THROUGH DEVELOPMENT OF SEASON-CRACKS ON STORAGE. THE AMOUNT OF SPRINGING-OUT IS AN INDICATION OF THE STRESS EXISTING BEFORE FRACTURE.

intercrystalline cracks which extend so long as sufficient tension exists at the end of the crack and mercury is available there to continue its action.

In soft and medium hard-rolled 70 : 30 brass mercury will cause cracking if the tensile stress is 6 to 8 tons per square inch. It is probable that in thin surface layers lower stresses may result in cracking under the action of mercury. Further work on this is in progress.

For general use mercurous nitrate is better than mercuric chloride for detecting stress; a solution containing 1 per cent. of mercurous nitrate and 1 per cent. of nitric acid is rapid and convenient in use.

The action of ammonia resembles that of mercury in producing an intercrystalline weakening, but extends to greater depths when prolonged. Indeed it appears that ammonia not only weakens the intercrystalline material in unstressed brass but causes an actual separation of the crystals. 70 : 30 brass immersed for long periods in ammonia solution may be crumbled in the fingers, and the fractures produced have the appearance of tarnished crystal surfaces. The gradual penetrating effect of ammonia on unstressed brass is illustrated by the loss of strength with increase of time of exposure to ammonia, and in this respect differs markedly from the effect of mercury.

The more brass is hardened by cold-work the better does it resist the intercrystalline weakening action of ammonia, but if sufficient time be allowed the hardest brass is affected.

A coating of mercury weakens copper only to a very slight extent.

THE INFLUENCE OF COMPOSITION OF COPPER ALLOYS ON SEASON-CRACKING.

1. *The Influence of Zinc Content.*—It has been well established that all industrial brasses are susceptible to season-cracking. No case of season-cracking of copper has come under observation, and the results given in the paper suggest that pure metal is immune from this form of failure. The following trials were carried out to indicate the effect of variation in zinc content.

Ingots containing 2·5 per cent., 6 per cent., and 9 per cent of zinc were prepared, together with an ingot of electrolytic copper to which a little manganese had been added for deoxidation. The hard-rolled and soft strip of each lot were made from the same ingot.

The ingots were cold-rolled into the form of strip 0·035 in. thick, and some pure zinc sheet of the same thickness was obtained for comparison. A proportion of the strip of each composition was annealed after the final cold-rolling.

Tests on Spun Cups.—Cups of the standard form and dimensions were spun from each kind of strip. The hard strip containing 10 per cent. of zinc was somewhat difficult to spin, and a small percentage of the cups made from it split at the edges in very much the same way as cups spun from 70 : 30 brass strip with a Brinell hardness of 126.

2. *The Influence of Manganese Content.*—In view of a suggestion which had been received that the presence of from 0·5 to 3·0 per cent. of manganese in 70 : 30 brass might inhibit season-cracking, the following trials were carried out: (a) The treatment of cups spun from fully annealed sheet 0·035 in. thick (with a Brinell hardness of 52 for the 0·5 per cent. manganese alloy and 61 for the 3 per cent. manganese alloy) with (1) mercurous nitrate solution and (2) ammonia. (b) The treatment with mercurous nitrate solution of strips of hard-rolled sheet stressed by bending. (c) Storage under different conditions of strips of hard-rolled sheet stressed by bending.

Composition of Alloys.

	U.	V.
Copper per cent. ...	71·5	71·2
Manganese per cent. ...	0·52	2·90
Zinc per cent. ...	... remainder	remainder

Both alloys were made from materials of a high standard of purity.

Rolling and Annealing of Alloys.—The alloys were observed to harden in rolling more rapidly than 70 : 30 brass; tests indicated that a given reduction increased the Brinell hardness considerably more, and cracks

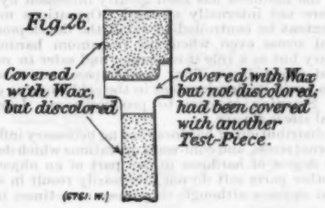


Fig.26.
Covered with Wax, but discolored
Covered with Wax but not discolored; had been covered with another Test-Piece.
(STG. W.)

appeared at the edges at a much earlier stage than in 70 : 30 brass.

Tests on Spun Cups.—Five cups of each alloy and five cups spun from soft 70 : 30 brass were immersed for 5 minutes in a 1 per cent. mercurous nitrate solution containing 1 per cent. of nitric acid, after the standardized pickling treatment. The time in which cracks first appeared was noted and all appeared to crack equally readily, while as regards number and extent of cracks there was nothing to choose between the three alloys. Two cups of each alloy were pickled in nitric acid and after washing and drying were placed in an enclosed space (containing some air) over 0·880 ammonia solution. They were found to be badly cracked after two days' storage. Cups spun from 70 : 30 brass behaved in an identical way.

A hard-rolled strip showed the same type of fracture in all cases, the cracks in the early stages running across the outside layers of the strip and at right angles to the edges, while as the cracks developed they tended to run parallel to the rolled surfaces of the strip, producing layers similar to those shown in Fig. 25. All fractured surfaces were coated with mercury.

Storage Trials.—Strips 1·2 in. wide of 70 : 30 brass, the 0·5 per cent. manganese and the 2·9 per cent. manganese alloy, stressed by bending round wooden blocks and polished as described, were stored in a well-ventilated room and in the open air, but protected from rain. The trials commenced in July, 1919. The rings were examined at intervals of one month; the rings in the room were only slightly tarnished, and were not cracked after nine months' storage. The rings stored in the open air did not tarnish nearly so badly during the summer as during the winter months, when corrosion was quite marked. Surface cracks were observed at the end of six months in the strip 0·1 in. thick containing 2·9 per cent. of manganese on rings 4 and 12 in. in diameter, and at the end of nine months the rings had completely fractured, the fractures running generally parallel to the rolled surfaces of the strip as shown in Fig. 25. There were no signs of cracking in the 70 : 30 brass and 0·5 per cent. manganese alloy stored under the same conditions, and none of the rings stored indoors had cracked.

3. *Phosphor Bronze.*—The cracking in ammonia of cups from phosphor bronze has been described above. Similar cups cracked after coating with mercury by immersion in mercurous nitrate or mercuric chloride solutions. Mercurous nitrate produced the better coating. In no set of conditions did the phosphor bronze cups crack so readily as the brass cups, although internally stressed to a similar extent.

4. *Summary.*—Stressed zinc-copper alloys do not crack under the action of mercury or ammonia if the zinc content is below about 6 per cent., and the higher the zinc content the more readily does cracking occur. It is probable that the action of mercury and ammonia is a reliable index of the liability to the development of season-cracks, and that therefore season cracking is not to be expected in copper or in its alloys with small percentages of zinc. The results of extensive trials with 70 : 30 brass containing small amounts of manganese indicate that these alloys when stressed crack quite as readily or more readily than pure 70 : 30 brass when submitted to the action of mercury or ammonia, and cracks have resulted after atmospheric corrosion; no indication that the presence of manganese reduces the liability to the formation of season cracks has been obtained.

Stressed phosphor-bronze is cracked by mercury or ammonia, though much less readily than brass, and may possibly be subject to season-cracking if the conditions are sufficiently severe, but no example of season cracking of phosphor bronze in service has come under notice.

SOME FURTHER EXPERIMENTS AND NOTES.

1. *The Relation of Season-cracks to Surface Defects.*—During the examinations of numerous specimens which had developed season cracks or had been cracked by mercury or ammonia treatment, special attention was paid to the occurrence of surface marks and defects, to ascertain whether these were related in any way to the cracks. It was very rarely that surface defects such as laps, score marks, and spinning or tool marks were connected with the cracks in any way, though such surface defects were abundant and cracks were hardly ever connected with inclusions.

Where seams occurred in specimens cracked by mercury or ammonia there was a tendency for the mercury and ammonia to pass along these when they were clean, but if oxidized the mercury did not pass along them, and ammonia appeared to have little effect except that in some cases open seams of this kind aided penetration of ammonia into the interior of the brass.

In a number of cases cracks were observed to begin at stamp marks, especially if these were deep; this effect was probably due to the presence of fairly high tensile stresses at the edges of the stamp marks.

2. *Protective Coatings.*—The failure of some protective coatings to prevent the chemical action, on the surface of stressed brass, which induces cracks, has already been noted. A number of instances of season-cracking occurring without visible corrosion have been observed in articles having a continuous coating of lacquer.

The coating with paraffin wax of the ends of test-pieces before exposure to ammonia gas afforded a good opportunity for the study of the diffusion of ammonia through the wax. It was noticed that a large number of test-pieces were discoloured under the wax after treatment, but that in specimens on which another test-piece had rested during exposure to ammonia there was a well-defined untarnished area under the wax corresponding exactly to the area in contact with the upper test-piece, as illustrated in Fig. 26. The tarnish under the wax was slight compared with the corrosion on the unwaxed parts.

These observations indicate that the coating of wax retarded the attack of ammonia, but that some ammonia diffused through the wax coating. The sharp outline of the untarnished areas showed that there was little lateral diffusion of ammonia under the wax.

Cups of the standard form and dimensions spun from fully annealed 70 : 30 brass and coated with a continuous thick layer of paraffin wax were placed over 0·880 ammonia. They became very slightly tarnished and had lost their "ring" at the end of 40 hours, and cracked after 60 hours. Spun cups which had been coated with a thick layer of copal varnish and stoved at 150 deg. C. for six hours were placed in a closed space over 0·880 ammonia. The cups became slightly tarnished under the lacquer coating at the end of one hour; at the end of two hours the cups had lost their "ring," and large cracks had developed in eight hours. Even when the cups had lost their "ring," a sign of incipient cracking, there was no marked corrosion.

3. *Fire-cracking.*—Various methods of unequal heating, such as dipping part of a cup in a salt bath at high temperatures and placing cups in a hot furnace, were tried in order to ascertain whether spun cups (70 : 30 brass) could be cracked by heating. The only way in which cracks were produced was by impinging a blow-pipe flame at one point on the cup. Fig. 18, page 298 *ante*, shows the intercrystalline character of cracks produced in this way.

4. *The Removal of Stress by Reeling.*—The material used in these experiments was 70 : 30 brass rod:

	Average Diameter. In.
S, hard drawn	0·5730
R, the same rod but reeled after drawing	0·5730
T, S rod hard drawn to a smaller diameter	0·4469

The structures in the material S and R were very similar

consisting of much-twinned *a* crystals, while in the material T the crystals were smaller. Sections from each bar were pickled and immersed for five minutes in 1 per cent. acid mercurous nitrate solution. Sections from S cracked before removal from the solution; the cracks were circumferential and were connected by longitudinal cracks; they extended on keeping. Sections from R had not cracked in 96 days after the mercurous nitrate treatment. Sections from T developed longitudinal cracks in the solution which extended afterwards until they gaped badly. No circumferential cracks developed, even after long storage. The results afford confirmation of the removal of internal stress by reeling.

5. *The Effect of Temperature on Season-Cracking.*—In view of the suggestions which have been made that raised or alternating temperatures may favour the development of season-cracking, the following trails were carried out.

(*a*) *Raised Temperature.*—Spun cups were placed in an air oven maintained at 100 deg. C.

Six cups spun from fully annealed brass and pickled.

Four cups spun from fully annealed brass and very lightly polished with 000 polishing paper.

Two cups spun from hard brass and pickled.

Two cups spun from hard brass and polished as described above.

At the end of 365 days the cups were slightly tarnished, but none had cracked. To confirm that the cups were still in a state of internal stress, one pickled and on polished cup spun from fully annealed brass and one polished cup spun from hard brass were pickled and immersed in 1 per cent. mercurous nitrate solution for five minutes. The time required to develop cracks was slightly longer than for similar cups which had not been heated, but the cracks were very similar in form and number.

(*b*) *Alternating Temperatures.*—Cups spun from fully annealed brass and others spun from hard brass were subjected to alternating periods of 24 hours at 100 deg. C. and 24 hours at atmospheric temperatures, the cups being allowed to cool rapidly. At the end of 365 days none of the cups had cracked. The results show that 365 days at 100 deg. C. does not appreciably reduce the internal stress, while neither this treatment nor the treatment of cups at alternating temperatures of 100 deg. C. and atmospheric temperatures produces cracks in the cups.

Summary and Conclusions.

The bearing of some of the results obtained has been discussed in the preceding summaries, which conclude the sections of this paper. The more important conclusions, some of which confirm the work of others who have studied this subject, may be briefly stated as follows: (1) Season-cracking occurs in a great variety of industrial brasses, differing widely in composition, degree of purity, micro-structure, and physical properties. (2) Season-cracking occurs only in material which is maintained in a state of stress, either by external constraint or more commonly by internal stress. (3) Corrosion of the surface and sometimes of the walls of the cracks is frequently associated with season-cracking but corrosion effects are not always visible. (4) Season-cracking may occur in brass coated with continuous protective layers, such as lacquer. (5) Nickel-plating is probably completely effective in preventing season-cracking, if a sufficient and continuous cont of nickel is secured. (6) Highly stressed articles, capable of developing season-cracks in certain conditions, may be kept for years in reasonably pure atmospheres without showing any sign of cracking, and there appears to be no reason to anticipate the development of cracks so long as the condition of the surrounding atmosphere does not change. (7) Some agency additional to the presence of initial stress appears to be necessary for the development of season-cracks. (8) Surface defects which might localise stress, and working or other imposed stresses additional to the initial stress, do not appear to contribute to the development of season-cracks in brass to any important extent. (9) Corrosion does not necessarily favour the development of season-cracks in stressed brass. Very severe corrosion and pitting caused by the prolonged action of various acids and other corrosive agencies had no cracking effect on stressed brass liable to develop season-cracks in other circumstances. (10) Mercury, ammonia, and ammonium salts readily produce cracks in brass which is sufficiently stressed in tension. (11) Season-cracks almost invariably follow an intercrystalline path. They occasionally cut through a crystal when the path round it is much longer, but resume their intercrystalline path on the other side. The intercrystalline nature of the cracks is a most marked and characteristic feature of season-cracks. (12) The cracks produced in stressed brass by mercury or by ammonia are of the same intercrystalline type as season-cracks. (13) The investigation of certain examples of rapid season-cracking indicated ammonium salts acting on stressed brass as the cause of the cracking. (14) Ammonia has been detected in a water extract of slightly corroded fractures caused by season-cracking in brass corroded by atmospheric action only. Reason was found to suspect the presence of small amounts of ammonia in the atmosphere in which the specimens were stored. (15) It is probable that traces of ammonia in the atmosphere are an important agency, and possibly the main agency, inducing season-cracking of stressed brass. (16) Ammonia appears to have a specific and selective action upon the intercrystalline material of brass, weakening it sufficiently to cause cracking if in tension. Mercury has a similar intercrystalline weakening action. (17) Season-cracks and the similar cracks caused by mercury or ammonia always begin in surface layers which are in tension. (18) The greater the degree of hardening by cold-work the less is the brass affected by the intercrystalline weakening action of ammonia or mercury, although it is probable that weakening may occur whatever the hardness of the brass. (19) It is probable that the behaviour of a copper alloy submitted to the combined effect of tension and of ammonia or mercury is a reliable index of its liability to fail by season-cracking. (20) Liability to the development of season-cracks appears to diminish as the zinc content of brass is reduced. It is considered that copper and zinc-copper alloys containing less than about 10 per cent. of zinc are unlikely to fail by the development of season-cracks in service. (21) The addition of manganese to brass does not appear to reduce its liability to fail by season-cracking. (22) Protracted heating of highly stressed 70 : 30 brass at 100 deg. C. does not develop cracks and does not reduce the stress appreciably.

The important practical question of the prevention of season cracking by the removal of initial stresses has been previously dealt with by the authors.* While reeling and similar mechanical methods may be effective in some cases, their application is limited and it might be difficult to ensure their efficacy in practice. A suitably controlled low-temperature annealing which will remove stress sufficiently to ensure freedom from season-cracking with little or no effect on the hardness appears to be the most effective safeguard against failure by season-cracking and might well be applied to all brass articles made by cold-work operations capable of inducing permanent internal stress.

The wide divergencies in composition, structure, and physical condition of brass articles which have failed by season-cracking, together with the ease with which stressed brasses of very different compositions or of the same composition but differing in structure may be made to develop "season-cracks" by ammonia treatment, suggest that within the limits of, say, 25 per cent. to 45 per cent. zinc little improvement in resistance to season-cracking is likely to be obtained by changes in composition or treatment if the state of initial stress is not affected. The apparent advantage of harder-worked brass in resisting season-cracking is largely discounted by the higher stresses which are likely to exist in harder brass if steps are not taken to remove them. It is obvious that stresses present in brass cannot exceed the yield point (regard being paid to the raising of the yield point which may have been brought about by local or general overstrain), and for this reason it is probable that in practice soft brass is unlikely to fail by season-cracking since the stresses which can exist in it are low. Season-cracking has, however, been frequently observed in brass only slightly hardened by cold-work, but no example has yet come to notice in fully annealed brass.

It is probable that in much material which has failed by season-cracking the initial stresses (internal or other) were very high. It may not always be realized what high stresses may be caused by external constraint since the elastic deformation corresponding to a high stress is so small.

Cold-work operations do not necessarily leave high internal stresses in the worked article. Many objects in which the hardness has been greatly increased by cold-work are not internally stressed. Operations may to some extent be controlled to avoid the development of internal stress even when the maximum hardness is necessary but as a rule it is simpler and safer to remove internal stress by a final low-temperature annealing than to avoid its development in the cold-working operations. Spinning appears to produce some degree of internal stress always.

The distribution of hardness has no necessary influence on internal stress, and cold-work operations which develop a high degree of hardness in one part of an object and leave other parts soft do not necessarily result in severe internal stresses although they may sometimes induce them.

Ammonia corrodes brass rapidly, and the corrosion so commonly accompanying season-cracking is consistent with the suggested action of ammonia in causing season-cracking. Marked intercrystalline weakening may, however, be induced by ammonia when no general corrosion can be detected, and the authors' view is that the general corrosion so often accompanying season-cracking should be regarded not as a cause of cracking but as another effect of the agency which has induced the cracking of the stressed brass. The selective corrosion of β-crystals in a β-brasses by ammonia, and also at the borders of season-cracks, is a marked and interesting feature.

Brass articles in which the presence of very high internal stress was revealed by mercury treatment fifteen years after manufacture had not developed season-cracks. The explanation would appear to lie in the absence of a sufficient amount of the "accelerating agent," ammonia, in the atmosphere of storage.

Since brass which develops season-cracks is often very ductile, the suggestion, frequently advanced, that local defects in the surface may cause stressed brass to develop season-cracks is not thought to afford a probable explanation. Local concentration of stress at a groove or other fault in the surface should be relieved by local stretching.

Trials in which highly stressed brass was heated at 100 deg. C. for a year failed to yield any indication that a raised temperature favours the development of season-cracks. Alternation between 100 deg. C. and room temperatures continued for a year was similarly without effect.

It is considered that this study of season-cracking and of the action of mercury and ammonia on stressed brass affords strong support to the hypothesis of an intercrystalline material differing essentially in its properties from the crystals themselves. In the case of, for example, a pure *a*-brass, the intercrystalline material appears to be attacked by ammonia or by mercury much more rapidly than the crystals. The mercury probably alloys with the intercrystalline material, forming a mechanically weak alloy, while ammonia forms a chemical compound possibly of the nature of a cupramine. The apparent presence, on spun cups and on other cold-worked articles, of a layer which retards the intercrystalline weakening action of both mercury and ammonia, is an interesting confirmation of the view that the intercrystalline material is similar in its properties to the amorphous film produced by surface flow. The operation of spinning would be expected to produce a very definite surface film of Beilby's amorphous phase, and possibly, in addition, a thin lower layer of very severely deformed material containing a high proportion of amorphous phase. If the amorphous material is more capable of combining with or absorbing ammonia or mercury than the crystalline material, it might be expected to exercise some protective action, since the mercury or ammonia would be unable to act on the boundaries of the crystals below until the surface layer had become "saturated." The more rapid apparent disappearance of a thin mercury coating from the outer surface of a spun cup, in comparison with a similar cup from which the flowed surface layer had been removed by pickling before mercury treatment, would confirm this suggestion. The "disappearance" of the mercury coating was probably due in part to absorption of free mercury by the amorphous material in the surface layer. This applies to very thin coatings only; thicker deposits do not disappear except by volatilisation, and there is little or no diffusion of mercury to an appreciable depth in brass.

The greater resistance of hard-worked brass to the intercrystalline weakening action of mercury or ammonia may be explained by the much larger proportion of amorphous phase, much of which is assumed to exist within the deformed crystals. The capacity of hard-worked material for absorbing mercury or combining with ammonia should be much greater if the view be adopted that the amorphous material plays the chief part in such reactions. Since the amorphous phase is much more uniformly distributed in cold-worked brass, the selective weakening action is less concentrated at the intercrystalline surfaces. The more severe the cold-work the less should be the selective action at the crystal boundaries, and this is borne out by the diminished intercrystalline weakening as the hardness increases.

It does not appear to be necessary to ascribe peculiar mechnical properties to the intercrystalline substance in order to explain the phenomena of season-cracking and the authors are unable to find in the results of their work any evidence indicating that season-cracking is the result of viscous flow of the intercrystalline cement. The undoubtedly intercrystalline character of season-cracks in brass appears to be fully explained by the selective weakening action of a chemical substance on the intercrystalline material. In this particular the authors' view of season-cracking in brass differs from that of Rosenhain and Archbutt, although there is agreement in so far as their explanation is also based on the assumption of an intercrystalline material probably identical in its properties with Beilby's amorphous phase found in surface films.

* H. Moore and S. Beckinsale, "The Removal of Internal Stress in 70:30 Brass by Low Temperature Annealing." *Journal of the Institute of Metals*, No. 1, 1920, vol. xxiii, p. 225.

APPENDIX.

Notes on Methods and Tests.

For certain details of frequently applied testing methods an exactly defined procedure was adopted and adhered to throughout the work reported in this paper.

Pickling.—The brass specimen was immersed for 30 seconds in a mixture of 40 volumes of nitric acid 1·42 sp. gr. and 60 volumes of water, at room temperatures, and was thoroughly washed in running water immediately on removal from the pickling bath. If immersion in a solution (such as mercurous nitrate solution) was the next operation, the specimen, wet after washing, was transferred directly to that solution. For other tests (*e.g.*, a mechanical test, storage over ammonia solution, a keeping trial) the pickled specimen, after washing in water, was rinsed with acetone and allowed to dry in the air. The nitric acid used is sometimes referred to as 50 per cent. nitric acid, this being its approximate strength by weight. Pickling, throughout this paper, indicates the above procedure, unless it is otherwise stated.

Mercurous Nitrate Solution.—The most frequently used solution contained 1 grm. $Hg_2(NO_3)_2 . 2H_2O$ crystals and 1 c.c. nitric acid 1·42 sp. gr. in 100 c.c. solution, and was made up with distilled water. Wherever the expression 1 per cent. mercurous nitrate solution occurs in this paper this is the solution indicated. 500 c.c. was the usual allowance for the treatment of a spun cup.

Nessler Solution.—180 grms. of potassium iodide were dissolved in 250 c.c. of water, and the solution was poured upon 70 grms. of mercuric chloride contained in a glazed mortar. The mixture was triturated until all solid matter was dissolved and made up to 2,500 c.c. by the addition of ammonia-free distilled water, 454 grms. of potassium hydroxide were added, and when this was dissolved the solution was cooled and a saturated solution of mercuric chloride was added until a slight permanent precipitate was obtained. The solution was then made up to 3 litres and cleared by standing. The clear solution was decanted and kept in a bottle with a closely fitting ground stopper.

The Detection of Traces of Mercury in Brass and Copper.—The copper or brass was dissolved in nitric acid, evaporated to a syrup taken up in water, and sufficient nitric acid was added to dissolve any oxynitrate formed. The solution thus obtained was drawn over freshly precipitated copper contained in a glass bulb of about 10 c.c. capacity, the copper being retained in the bulb by a plug

of ignited asbestos at each end. The solution was passed over the copper twice, and the copper (which was retained in the bulb) was then washed with a 5 per cent. hydrochloric acid solution, water, and alcohol, and dried for several hours at 100 deg. C. The bulb containing the copper was connected up with a narrow tube containing potassium iodide crystals, and after gentle heating to 100 deg. C. in a current of air to remove the final traces of moisture, the bulb was heated to 400 deg. C. to drive off all mercury. When mercury is present the potassium iodide crystals become yellow. As has been stated previously, clear indications have been obtained of the presence of 0·00002 gramme of mercury.

Spun Cup.—Unless it is otherwise indicated, the expression "70 : 30 brass spun cup" occurring in the paper signifies a specimen conforming exactly to the description given in the authors' earlier paper, and is a small flanged cup spun from fully annealed 70 : 30 brass sheet 0·035 in. thick and not submitted to any heat treatment during or after spinning.

Tensile Tests.—In every case elongation was measured on a gauge length $l = 4\sqrt{a}$, where a = area of cross-section of the test-piece, in accordance with certain standards adopted by the British Engineering Standards Association.

Brinell Hardness Tests.—All tests were made with a ball of 1 mm. diameter and a load of 10 kg., or if with a larger ball, the load was increased in proportion to the square of the diameter (*e.g.*, 2 mm. diameter ball, 40 kg. load), giving strictly comparable Brinell hardness numbers.

CATALOGUES.

Cast Iron Pipes.—The Stanton Ironworks Company, Limited, Nottingham, continue to issue their useful monthly lists of cast iron pipes in stock ready for immediate dispatch.

Roller Bearings.—The application of their flexible roller bearing to many different types of elevator and conveyor plant is described in a new special catalogue issued by Messrs. Hyatt, Limited, 4, Thurloe-place, London, S.W.7.

Gauges and Die Heads.—Three leaflets describing inside and outside screw gauges, adjustable snap gauges and self-opening die heads come from Messrs. Alfred Herbert, Limited, Coventry. Full particulars of working dimensions and prices are given for a large range of sizes in all cases.

Woodworking Machines.—A catalogue of circular saw benches and machines for fret sawing, boring and slot-mortising, gulleting, tenoning, and chain mortising has come to hand from Messrs. Watts Brothers (Sheffield), Limited, Keeton's-hill, Sheffield. Some of these machines are for hand drive and particulars of several tools and tool-dressing appliances are included in the catalogue.

Electrical Machinery.—A catalogue of motors, dynamos, motor generators and direct-coupled steam and oil engine sets, made by Messrs. McClure and Whitfield, Stockport, comes from their agents, the City Electrical Company, Limited, 1, Emerald-street, Holborn, London, W.C.1. Some excellent illustrations and a price list with full particulars of machines up to 90 b.h.p. are included in the catalogue.

Marine Geared Turbines.—The impulse type of steam turbine driving through double reduction gear is the subject of a special catalogue issued by the Metropolitan Vickers Electrical Company, Limited, of Manchester. The contents includes particulars of the general construction of the turbines, gearing, condenser and auxiliary plant, notes on superheat and vacuum and illustrations of several sets supplied by the firm. The descriptions are very clear and well illustrated.

Reduction Gears.—A very large range of reduction gear sets, enclosed in grease-proof boxes, with driving and driven connections are described in a catalogue to hand from Messrs. Joseph Baker, Sons and Perkins, Limited, Kingsway House, Kingsway, London, W.C.2. The standard sizes comprise gear ratios from 4 to 1 to 12 to 1, and fourteen other sizes made have ratios ranging from 15 to 1 to 285 to 1. In each case a considerable variety of capacities is provided, powers as low as 2-h.p. and as high as 65-h.p. being specified.

Pumps.—The catalogue of pumps issued by Sir W. H. Bailey and Co., Limited, Salford, is of a very comprehensive character, including particulars of drain pumps for high pressures and high lifts, rotary and semi-rotary pumps, special pumps and fittings, power pumps with all forms of drives, hand pumps, and pumps operated by animal power; air pumps and blowers are also included. The object of the firm is to provide the most suitable forms for all ordinary requirements, such as water supply, well pumping, drainage, fire extinguishing, sewage pumping and the pumping of oils, tar and other liquids. Each type is illustrated, and dimensions, capacities and prices are stated.

Furnace Charging Machine.—A machine for inserting parts into furnaces for heat treatment and also for withdrawing them is shown in a catalogue received from Messrs. Gibbons Brothers, Dudley. The parts are arranged on a plate, which is carried on a truck, operated by hand or by an electric motor. The truck may be moved from one furnace to another of a series and the plate is pushed into or hauled from the furnace, which is fitted with special rails and guides. Both movements are effected through gearing. Various sizes are made, the largest being suitable for furnaces 25 ft. long and 6 ft. wide, and the makers state that the machines will work satisfactorily with furnace temperatures up to 1,100 deg. C.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

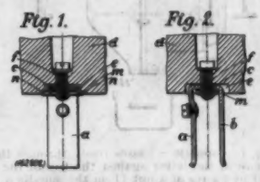
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

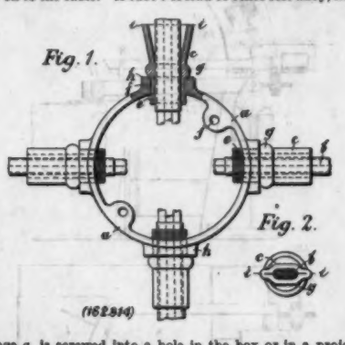
ELECTRICAL APPARATUS.

162,602. W. T. Henley's Telegraph Works Company, Limited, London, and W. S. Wakefield, Northfleet. Electric Fuse Carriers. (3 *Figs.*) November 29, 1920.—The spring contacts for electric fuse carriers and other electric fittings are mounted so as to permit a certain freedom of movement in order that they may be self-adjusting or self-aligning in relation to the contact block. The spring contact *a*, *b* is formed, as usual, from a strip of metal bent to substantially



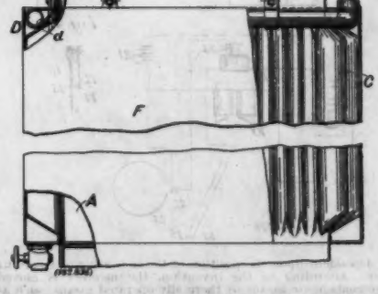
U-shape and is held in position with its web *c* in a recess *e* in the porcelain insulating body *d* of the fitting, by a screw *f* passing through the body *d* and freely through the web *c*. The screw *f* engages a nut *m* in the form of a strip of metal, lying between the jaws of the contact and transversely of, and projecting beyond, the web. The ends of the strip nut *m* are contained in recesses *n* in the body *d*. The construction permits slight freedom of movement of the contact, but prevents it from moving to such an extent as to foul the contact block over which it is to be sprung. (*Sealed.*)

162,814. R. S. Woods, Longsight, Manchester. Junction Boxes. (4 *Figs.*) February 7, 1920.—Electric cables are secured to junction and distribution boxes by means of a short tube of soft metal or alloy connected to the box, and through which the cable is passed, the projecting end of the tube being compressed firmly on to the cable. A tube *c* of lead or other soft alloy, having



a flange *g*, is screwed into a hole in the box or in a projecting boss *h*. After leading in the cable *b* a suitable tool is used to press the outer end of the tube into an oval shape upon the cable and the laterally-projecting portions *i*, Fig. 3, are then further pressed together close up to the cable to lock the latter in place. The internal cross-section of the tube may approximate to the shape of the cable to be secured. (*Sealed.*)

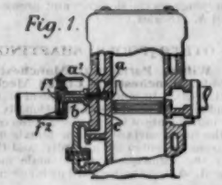
162,836. The Hackbridge Cable Company, Limited, Hackbridge, and W. C. Kennett, Hackbridge. Electric Transformers. (2 *Figs.*) February 16, 1920.—An electric transformer enclosed in a tank A, is cooled by passing water

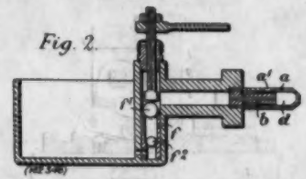


through a horizontally-disposed perforated pipe D. The water passes through the perforations and descends between the walls C, which are preferably corrugated, and an outer casing F of the tank. (*Accepted May* 19, 1921.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

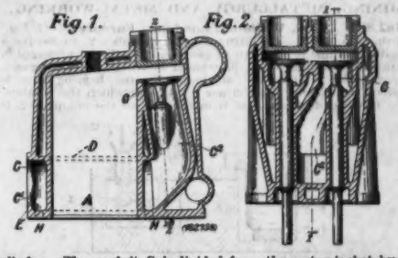
162,548. W. H. Kane, Larne, and T. McClements, Larne. Injecting Liquid Fuel. (3 *Figs.*) May 15, 1920.—The internal-combustion engine to which the improvements refer is of the kind having a transfer port *c* in the engine cylinder, and an automatic fuel distributing and atomising device comprising outer and inner nozzles *a* and *b* located in the transfer port, with the outer nozzle *a* projecting beyond the end of the inner nozzle *b* so that on the uncovering of the transfer port by the piston, the vacuum thus created draws air and fuel into the space between the outer and inner nozzles. The novel feature consists in contract-





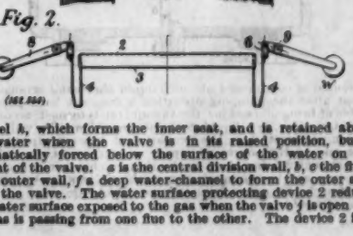
ing the end of the outer nozzle *a*, and making it of a shape to break up the jet of fuel issuing from the inner nozzle. The contracted end of the outer nozzle also prevents fuel dripping therefrom when the transfer port *c* is closed. *a*1 is a gap in the outer nozzle *a* for the admission of air to the space *d* between the ends of the inner and outer nozzles *b*, *a* respectively. The inner nozzle *b* is in communication with a fuel receptacle through a chamber *f* having non-return ball valves *f*1 and *f*2 therein. Two valves are provided so that if one gets out of order the other will generally remain in action. (*Sealed.*)

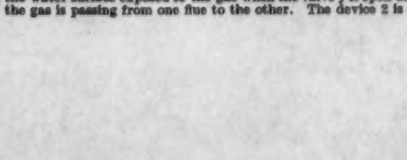
162,758. Sheffield-Simplex Motor Works, Limited, Tinsley, Sheffield, and W. Shackleton, Tinsley, Sheffield. Cylinder Construction. (4 *Figs.*) January 30, 1920.—In internal-combustion engines in which valves of the poppet type are employed, and in which a fuel-supply conduit has its opposite ends disposed at substantially opposite sides of the circumference of the cylinder A, with one end in communication with the inlet valve G and the other end connected with the induction pipe of the engine, the fuel-supply conduit C comprises, according to this invention, two branches which encircle the lower end of the cylinder A, and whose walls are in contact with the walls of the



cylinder. The conduit C is divided from the water jacket by a wall D. One end of the conduit opens into the port C1 at one side of the cylinder, the vertical faces surrounding the port being machined at E for good connection with the induction pipe. The branches of the conduit C unite in a common passage C2 extending up between the valve-stem bosses of the inlet and exhaust valves. The passage C2 is curved at its upper end so as to provide a passage which is approximately co-axial with the inlet-valve spindle. The conduit C is cast completely open at its bottom, and is subsequently closed by a ring H, seating on machined faces in the walls of the opening. (*Sealed.*)

162,564. W. Simons, Newcastle-under-Lyme, and I. B. Evans, Stoke-on-Trent. Gas Regulating and Reversing Valves. (7 *Figs.*) June 2, 1920.—In gas regulating and reversing valves for gas producers and furnaces of the type having water seals, the novel feature consists in the use of a mechanically-operated float 2 acting as a water surface protecting device. The device 2 is arranged in the shallow water



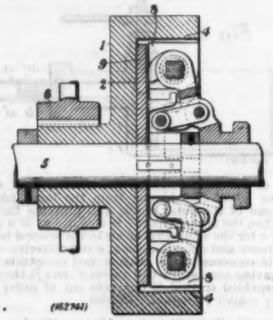


channel *h*, which forms the inner seat, and is retained above the water when the valve is in its raised position, but is automatically forced below the surface of the water on the descent of the valve. *a* is the central division wall, *b*, *c* the flues, *d* the outer wall, *f* a deep water-channel to form the outer seal, and *j* the valve. The water surface protecting device 2 reduces the water surface exposed to the gas when the valve *j* is open and the gas is passing from one flue to the other. The device 2 is of

hollow formation constructed of thin metal with the upper surface slightly curved and open at its base 3, but with the ends closed. Secured to the device 2 are plates 4 extending into the deep channel *f* and connected to links 6, each of the latter being connected to a lever 8 which is pivoted at 9 on a bracket fixed on the deep-water channel *f*. When the valve *j* is open for the passage of gas, the device 2 is retained in its normal position by balance weights *w*, the top of the device 2 being then a little higher than the water or on a level with the upper surface of the division wall *g*. The device prevents the gas playing on the water in the shallow channel *h*, and also prevents any solid particles in the gas depositing or falling into the water in the shallow channel *h*. When the valve *j* is closed, the projecting portion *j2* of the valve *j* engages the device 2 and presses it down in the shallow channel *h*. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

162,741. G. W. Willis, Patricroft, Manchester, and C. H. Berry, Moss Side, Manchester. Clutch Mechanism. (2 *Figs.*) January 24, 1920.—In clutch mechanism of the kind wherein coned male and female members are frictionally engaged and disengaged by the movements of blocks or segments comprised in the male member, the coned surface 4 of the female member 1 increases in diameter from the entrance inwardly, and the coned surface constituted by the segments 8 of the male member is correspondingly arranged, so that the forward or inner end of the

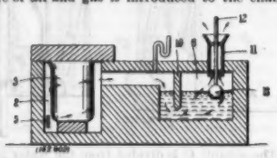


(162,741)

latter, when it is within the female member, is of larger diameter than the rear or outer end. The female member is mounted to revolve on the shaft 5, and is driven by or drives a pulley 6. The male member comprises two approximately semi-circular segments 8 and a disc or plate 9, which is disposed between the segments and the face 2 of the female member. The segments 8 and the disc 9 are mounted so as to be capable of sliding movement on the shaft 5, and are secured by keys against rotation. (*Accepted May* 19, 1921.)

MINING, METALLURGY AND METAL-WORKING.

162,802. H. S. Williams, London. Furnaces. (1 *Fig.*) February 5, 1920.—The furnace has a chamber 2 to receive a crucible 3, a flue for the exit of gases and a baffle 10 arranged in a tank 6 containing liquid interposed in the path of the gases, whereby the temperature attainable in the heating zone is appreciably raised. The burner 5, through which the combustible mixture of air and gas is introduced to the chamber 2, is



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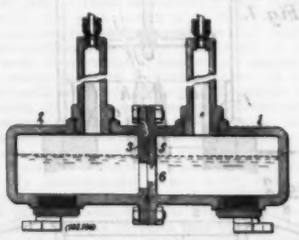
arranged tangentially to cause the flame to pass around the crucible 3 with a whirling or vortex motion. In the roof of the tank 6, a tube 11 is arranged, serving the dual purpose of allowing liquid to be introduced into the tank, and also allowing escape of the exit gases to atmosphere or otherwise. Mounted within the tube 11, so as to be capable of vertical motion, is a spindle 12 having a ball or float 13 at its lower end. (*Sealed.*)

MISCELLANEOUS.

162,180. Kelvin, Bottomley and Baird, Limited, Glasgow, and M. B. Field, Glasgow. Liquid Level Indicators. (2 *Figs.*) April 24, 1920.—In apparatus for indicating the depth of liquid in a tank of the type in which the measurement is effected by determination of the air pressure necessary to force the liquid out of an immersed balance chamber, and in which a vapour trap or liquid seal is employed to trap vapour which may be generated in the tank and which might otherwise find its way through the system of tubing to the gauge



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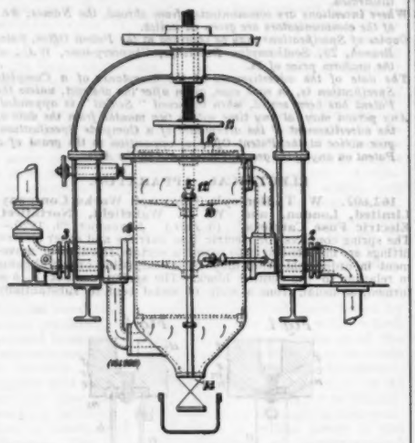
and source of compressed air, such liquid seal being arranged to present after the pumping operation a constant back pressure capable of being allowed for, the vapour trap is formed, according to this invention, as a liquid container partitioned by walls 3, 5 into compartments 1, 2, the compartment 1 being piped to the gauge and to the source of supply of compressed air, and the compartment 2 being piped to the balance chamber. The compartments are in communication with one another by way of an orifice 6, the upper boundary of which presents a sharp edge. (*Sealed.*)

161,993. J. Miller, Derby, and George Fletcher and Co., Limited, Derby. Filters. (1 *Fig.*) May 5, 1919.—The liquor to be filtered passes freely through the filtering medium which may have slight pressure applied to it, and the filtering chamber 4 is mounted about hollow trunnions 2, 3, through which it can be fed and exhausted. The novel feature consists in arranging the chamber 4 at one end to be closed by a rapidly-operated cover 6, separately mounted from it, and providing at the opposite end a stop cock 14 to allow the draining off of mud or sediment whilst the filter is in use. A stop may be provided to maintain the filter chamber in its normal position



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of operation. The spindle 8 passes freely through the cover 6; packing pressure of the latter against the top of the chamber 4 being obtained by means of a nut 11 on the spindle 8. Rotation of the hand wheel 7 moves down a follower 10 on the spindle 8 until it contacts with the mass of filtering medium in the chamber 4. A test cock 12 is provided on the chamber 4 for testing the level of the liquid in it and a pipe and stop cock are provided for drawing off the liquor above the filtering medium prior to emptying the chamber of its filtering medium. (*Sealed.*)

163,739. G. F. Shotter, London. Integrating Apparatus. (6 *Figs.*) September 4, 1920.—Relates to mechanism for flow meters, watt meters and the like of the type comprising as arm or member which is operated periodically by a clockwork to actuate a counting mechanism, the movement of the member

Fig. 1.

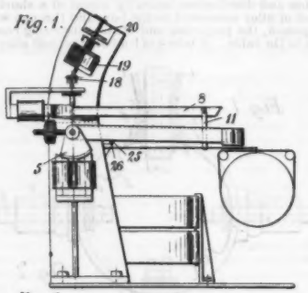


Fig. 2

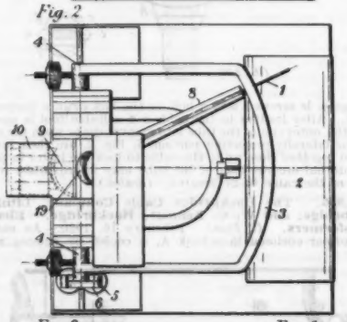


Fig. 3.

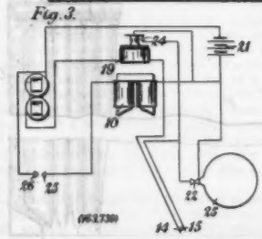
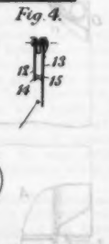


Fig. 4.



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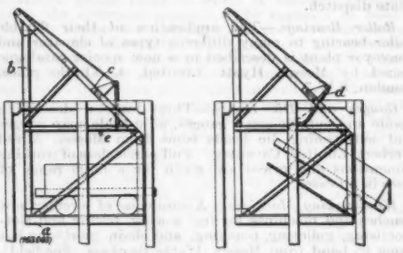
being dependent upon the position of the indicating or recording pointer. According to the invention, the member is moved by electromagnetic means or thermally-operated means, such as a bi-metallic strip, and an electromagnetically-operated locking means is provided for the indicating pointer, which means is operated periodically through switch contacts under the control of the clockwork. An electromagnetic clutch is provided to connect the member to the counting mechanism, and a switch contact on the member is adapted to open the electric circuits when the arm reaches the position of the indicating pointer, whereupon the member and locking device are returned to normal position. As shown in Figs. 1 and 2, the indicating or recording pointer 1 moves over a recording chart 2 and a curved locking bar 3, pivoted at 4, and carrying an armature 5 is adapted to engage the pointer to hold it in set position at predetermined intervals, by the energisation of the electromagnet 6. Disposed above the bar 3 is a traversing arm 8, which is provided at one end with an armature 9 co-operating with an electromagnet 10, and at the other with a switch contact 11 comprising two arms 12, 13, Fig. 4, and corresponding contacts 14, 15, the arm 13 extending into the path of the pointer 1. The traversing arm 8 is connected through gearing 18 and an electromagnetic clutch 19 to a counting mechanism 20. The electric connections are shown in Fig. 3, in which 23 represents a clock-driven cam adapted at intervals to close a switch 22, whereby current flows from a source 21 through the contacts 14, 15, to the clutch 19 and electromagnet 6. The switch 22 is short-circuited by a switch 24 operated by the clutch 19. The movement of the locking bar 3 closes a switch 25, 26, Figs. 1 and 3, in the circuit of the electromagnet 10, thereby operating the traversing arm 8 and counting mechanism 20, until the arm 13 is swung by the pointer 1 to open the circuit of the magnet 6. In a modification, the locking bar is adapted to depress the indicating pointer through a constant distance during part or all of which the pointer is in contact with a sloping edge of a rocking member, which is adapted to actuate the counting mechanism. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

163,063. E. F. Sargeant, Hull. Coal Trucks. (6 *Figs.*) November 13, 1919.—For discharging coal trucks, the wagon-lift *a* is provided with a superstructure *b* carrying a dependent pusher *d* adapted to be thrust downwardly between the rear end of the truck and the load and to advance under power in a direction to discharge the load. The pusher *d* has a rearwardly-depending scraper or hoe *e*. The pusher is pivoted to a sliding member *c* which is moved along the inclined frame member by hydraulic or other means. When the truck is tipped, the pusher is swung back by hand from its normal vertical position into



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engagement with the rear wall of the truck. Further tipping of the truck then moves the pusher down to the bottom of the truck in contact with the rear wall. At the same time the hoe is folded up automatically to lie flat against the pusher. The sliding member *c* then is actuated to push the material from the truck, and during the operation the hoe falls down and follows the pusher, thus scraping off all residual material adhering to the walls. The final clearance of the material is effected by the pusher swinging back to its vertical position from near the end of the truck. (*Sealed.*)

163,385. W. Redpath, Leeds, and The Leeds Forge Company, Limited, Leeds. Railway Vehicle Underframes. (4 *Figs.*) January 2, 1920.—In railway vehicles provided with central buffers or central buffer couplings, a pair of pressed steel longitudinal members *a*, each of channel section, and formed with a longitudinal corrugation *f* in its web portion, is attached to the transverse members *h* of the underframe for resisting the compressive stresses due to buffing. The longitudinal corrugations *f* are formed at about the middle of the

Fig. 1.

Fig. 2.

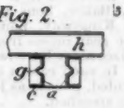
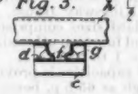


Fig. 3.



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greatest depth of the web and project at the deep end portions in the same direction as the flanges and at the middle shallow portion in the reverse direction. The top or bottom flange, or both, may be tapered from a lesser to a greater width between the headstocks and the first cross-bars. The striking plates *i* and carriers are secured to the closed ends of the longitudinal members. (*Sealed.*)

Titanium Hydride.—Within the last few years Paneth has shown that bismuth, lead and tin combine with hydrogen, forming hydrides like arsenic, antimony and phosphorus. In the case of the lead hydride a peculiar electrolytic spark method had to be used, the lead cathode being coated with a cement of plaster prepared with glycerol (glycerin), through which sparks passed when the cathode was immersed in sulphuric acid on a high-frequency circuit. By this method A. Klauber, of Prague (*Zeitschrift für Anorganische Chemie*, vol. 117, pages 243–248, July 1), has succeeded in proving the existence also of a titanium hydride. It is a gas devoid of colour or odour, which catches fire spontaneously when exposed to the air, burning with a faintly luminous flame. That titanium absorbs hydrogen had been observed by E. A. Schneider, but the formation of a compound had not been proved, and all these hydrides are very difficult to isolate.